EUROPEAN ASSESSMENT DOCUMENT

EAD 120109-00-0107

August 2019

NOSING EXPANSION JOINTS FOR ROAD BRIDGES

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD covers nosing expansion joints for road bridges.

Nosing expansion joints for road bridges are used to ensure the continuity of the running surface and its load bearing capacity and the movement of the bridges whatever the nature of the structure constitutive material is.

This expansion joint has edge profiles prepared with metal, concrete, resin mortar or elastomer. The gap between the edges is filled by a flexible profile, which is not traffic load carrying.

Examples for different types of nosing expansion joints are given in Annex A.

Expansion joints for moveable bridges are not covered by this EAD.

A nosing expansion joint comprises (at least):

- Edge profiles made of metal runners, concrete, resin mortar or elastomer and their anchorage in the adjacent structure. The structural part which forms the edge profile in contact with the wheel loads shall be fully supported (e.g. as detailed in the Figures in Annex A); it shall only form a cantilever if it is designed to transmit the loads.
- A flexible sealing element made of vulcanised elastomer (e.g. based on Polychloroprenerubber (CR), Ethylene-Propylene-Diene Material (EPDM), Styrol-Butadiene-Rubber (SBR) or natural rubber (NR)) with a sufficient capacity to accommodate the movements, filling the gap between the edge profiles. The sealing element is not flush with the running surface and does not support the wheel.
- A single gap according to the definitions given in Clause 1.3.7 applies for nosing expansion joints.
- Connecting elements, as far as relevant according to the design.

A transition strip (as depicted in Annex A, key, case 1.3) made of thermosetting or thermoplastics binder (as defined in EN ISO 472[1]) or made of bituminous mixture or made of ready mixed concrete or resin mortar may be part of the product in terms of optional component.

The material used for connecting the joint to the substructure (e.g. concrete for recess filling and reinforcement in case of concrete bridges) considered in the assessment of the product shall be described in the ETA but is not forming a part of the product covered by the ETA.

The upstand is part of the kit.

Optional components (e.g. special adaptation for cyclists or pedestrian, drainage device made of aluminium or stainless steel (according to Annex D, Figure D.11), cantilever parts made of metal (e.g. traffic noise reducing elements), if part of the kit to be assessed, are addressed in the ETA. Such optional components are not intended to increase the movement capacity.

Nosing expansion joints according to this EAD are related to the atmospheric corrosivity categories C4 or C5 according to EN ISO 9223, whereas durability classes according to EN ISO 12944-1 and EN ISO 14713-1 respectively apply.

This EAD applies for products with the following corrosion protection aspects:

- Structural steel surfaces in contact with concrete have no coating. Only at the transitions an overlap of approximately 50 mm of the full corrosion protection system is applied.
- In case of use of stainless steel for components, the steel type is selected under consideration of the corrosivity categories of the atmosphere using the conditions given in EN 1993-1-4, Annex A, A.2, A.4 and A.5.
- Aluminium alloys have a corrosion resistance of at least category “B” according to EN 1999-1-1, Table D1, or equivalent. Furthermore, interaction between concrete and the aluminium alloy is prevented.
- Permanent steel bolts are at least electrolytic zinc plated. For coating with Fe/Zn 25 EN ISO 2081 applies, for hot dip galvanisation EN ISO 10684 applies. In case of stainless steel EN ISO 3506-1 applies, whereas EN 1993-1-4 Annex A, A.2, A.4 and A.5 needs to be considered.

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1 All undated references to standards or to EADs in this document are to be understood as references to the dated versions listed in Clause 4.

The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The product according to this EAD is intended to be used for road bridges.

1.2.1.1 Operating temperature categories

The operating temperature is defined as the shade air temperature according to EN 1991-1-5, clause 1.5.2.

The product according to this EAD is intended to be used under operating temperatures given below:

- Levels of minimum operating temperature categories: -10 °C, -20 °C, -30 °C, -40 °C
- Levels of maximum operating temperature categories: +35 °C, +45 °C

Operating temperature range shall be stated in the ETA.

1.2.1.2 Use categories

The use categories to be stated in the ETA are specified with regard to the user and action categories.

1.2.1.2.1 User categories

- Vehicle
- Cyclist
- Pedestrian

1.2.1.2.2 Actions categories

- Standard action (traffic load action)
- Optional action (accidental effects of heavy wheel on footpath, seismic phenomena; wheel shock on the upstand)

Actions are defined in Annex D, Clause D.2.3 and D.2.4.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the nosing expansion joint for road bridges for the intended use according to the working life categories as given in the Table below when installed in the works (provided that the nosing expansion joint for road bridges is subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

The intended working life of the kit is based on the following working life categories, with N_{obs} = 0,5 million/year (see EN 1991-2, Table 4.5 and Annex D, Clause D.2.3.3).

Working life categories of the expansion joint kit

Working Life category	Years
1	10
2	15
3	25
4	50

Replaceable components which have a working life shorter than for the kit shall be indicated in the ETA.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD (if necessary in addition to the definitions in CPR, Art 2)

For definitions, abbreviations and symbols regarding the terminology applying for assessment of mechanical resistance, resistance to fatigue and seismic behaviour Annex D applies. For additional terms and definitions specific for this EAD, see below.

1.3.1 Transition strip

Material between the expansion joint and the adjacent surfacing. Examples of transition strips are depicted in Annex A.

1.3.2 Anchorage system

Bars and/or rods that connect the nosing expansion joint to the main structure or the abutment. Examples of the anchorage system are depicted in Annex A.

1.3.3 Sealing element

A flexible element which ensures the watertightness of the nosing expansion joint.

1.3.4 Edge profile

Load bearing element forming the edges of the nosing expansion joint in longitudinal direction.

1.3.5 Secondary elements

Components of the kit not contributing to mechanical resistance and stability of the kit.

1.3.6 Batch

Quantity of product or components manufactured to the same specification within a determined period.

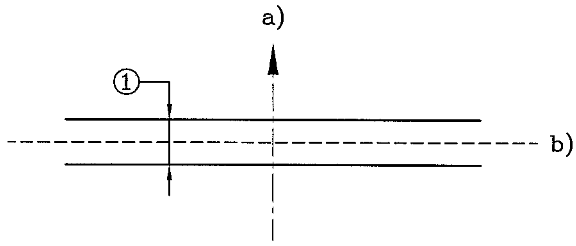
2 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

1.3.7 Gap

1.3.7.1 Expansion joint gap (surface gap (1))

Opening (generally defined by one dimension) with a great length and a relatively small width in the road surface between sub-components of the expansion joint (perpendicular distance between two straight edges or planes):

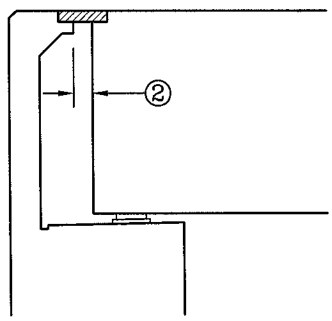
a) Traffic direction
b) Longitudinal axis of the expansion joint.



Note: In principle, the term gap is not restricted to straight border lines.
(See also Annex D, Clause D.2.2)

1.3.7.2 Bridge deck gap (structure gap (2))

Opening between two adjacent parts of the main structure, which is bridged by the expansion joint (distance between two structural elements) (See also Annex D, Clause D.2.2).



1.3.8 Kerb

The upstand which forms the boundary of the carriage way and the footpath.

1.3.9 Movement capacity

The range of the relative displacement between the extreme positions (e.g. maximum and minimum opening) of an expansion joint (See also Annex D, Clause D.2.2).

1.3.10 Recess

The specific opening over the expansion joint gap created by the installer/designer in order to receive the expansion joint kit.

1.3.11 Replaceability

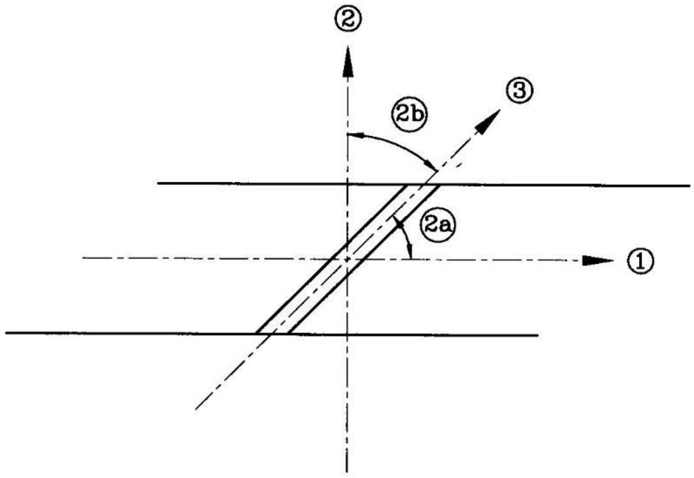
The ability to replace is given when a component, incorporated in the assembled expansion joint, can be exchanged during the intended working life of the expansion joint.

1.3.12 Skew angle (of the expansion joint)

Considering the existence of two interpretations of the skew of the bridge in Member States, it has two definitions:

a) the skew angle is the angle between the traffic direction and the longitudinal axis of the joint

b) the skew angle is the angle between the axis perpendicular to the road and the longitudinal axis of the joint



Legend

1: Road axis in traffic direction
2: Perpendicular to the road axis
2a and 2b: Skew angle
3: Longitudinal expansion joint axis
(See also Annex D, Clause D.2.2)

1.3.13 Upstand

The vertical or inclined part of the joint which ensures continuity of the joint between road surface level and footway level.

1.3.14 Void

An opening in the road surface (generally defined by two dimensions) with no load bearing capacity.

1.3.15 Traffic noise reducing elements

Load bearing surface elements with different geometries installed on the edge profiles with the purpose of reducing noise from over rolling traffic.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 1 shows how the performance of the nosing expansion joint for road bridges is assessed in relation to the essential characteristics.

Table 1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level
5	Cleanability	Clause 2.2.5	Description
6	Watertightness	Clause 2.2.6	Description
7	Durability	Clause 2.2.7	Description
Basic Works Requirement 3: Hygiene, health and the environment			
8	Content, emission and/or release of dangerous substances	Clause 2.2.8	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
9	Ability to bridge gaps and levels in the running surface	Clause 2.2.9	Level
10	Skid resistance	Clause 2.2.10	Level
11	Drainage capacity	Clause 2.2.11	Level Description

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

Testing will be limited only to the essential characteristics which the manufacturer intends to declare. If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

2.2.1 Mechanical resistance

Assessing the mechanical resistance of the nosing expansion joint shall not lead to:

- collapse of the whole or a part of the works
- major deformations to an inadmissible degree
- damage by an event to an extent disproportionate to the original cause

Assessment shall be based on:

- Relevant load distribution and load model according to Annex D, Clause D.2
- Actions (according to Clause 1.2.1.2.2) considered according to Annex D, Clause D.2.3 and D.2.4
- Safety factors used and assessment criteria according to Table 2

Calculations shall be done according to the conditions in the Eurocodes mentioned thereafter as far as relevant due to materials used and shall include information on calculation models used, whereas conditions and criteria defined thereafter shall be considered. Input from testing for calculation shall be introduced in the calculation, where relevant.

In case of testing, either in addition to or instead of calculation, as defined in the sub clauses thereafter, relevant components/assembled kit shall be referred to.

Assessment criteria used and based on the detailing thereafter shall be defined for the calculation.

In the ETA the assessment shall be stated in terms of description for the relevant product to be addressed (dimensions, materials, welds or bolted connections etc.).

Conditions for the assessment shall be stated in the ETA as far as relevant:

- Anchor forces for load distribution to the adjacent parts of the expansion joint
- the load models
- adjustment factors
- load factors
- combination factors

Whereas:

External loads on nosing expansion joints are generated by traffic. Further loads on expansion joints may be generated as internal loads from imposed deformations or displacements or change of temperature of the joint itself.

Table 2 gives details of the assessment criteria for concerned limit states.

Table 2: Limit state and assessment criteria

Limit State	Limit State requirement	Remark
ULS	Static equilibrium	Assessment criteria given in this EAD are related to the defined design situations in Annex D, Clause D.1. The nosing expansion joint includes its anchoring system.
	No fatigue failure during the intended working life (see Clause 1.2.2 in this EAD). (Stress ranges below constant amplitude fatigue limit [CAFL] or cumulative damage assessment D<1,0).	
SLS	Only reversible deformations, displacement or rotation (hysteresis effects or similar due to material behaviour are allowed).	

The ULS requirement for the nosing expansion joints is related to the maximum opening position and not influenced by imposed displacement at ULS of the main structure.

Annex D, Clause D.2 is relevant for the product according to this EAD with the following precisions:

- Generally due to the width in the traffic direction, the products according to this EAD are concerned only by the column $w_j \leq 1,2$ m of Annex D, Table D.2.
- Anchorages and transition strips (if part of the kit) shall be designed for the loads given in Annex D, Clause D.2.

The actions, loads and combination in relation to the user and actions categories described in Clause 1.2.1.2 are given in Annex D, Clause D.2.

Assessment of the minimum operating temperature according to Clause 1.2.1.1 for metallic components of the kit is done according to EN 1993-1-10, Table 2.1.

In deviation to the load distribution given in Annex D, Figure D.2, the following applies:

- The loads on the areas of Zones 5' and 5'' shall be added on the supporting area of Zone 3
- Load on Zone 4 is not added to the load on expansion joint area A'

In case of cantilever parts (e.g. nosing expansion joints with traffic noise reducing elements) made of metal, contributing to the mechanical resistance, for the load distribution, the conditions given in Annex D, Figure D.2, upper right sketch, apply.

The mechanical resistance shall be assessed by means of calculation according to Clause 2.2.1.1 in this EAD, if the resistances of materials and components can be derived from standards.

If assessment by means of calculation cannot be fully applied, complementary test(s) according to Clause 2.2.1.2 in this EAD and using the principles and conditions given in Annex D, Clause D.2 shall be used for assessment.

For nosing expansion joints without traffic noise reducing elements only vertical actions and horizontal actions in the traffic direction, given in Annex D, Clause D.2, shall be assessed.

Therefore, depending on the design of the nosing expansion joint, the force parallel to the joint axis is considered to be transferred to the joint as a whole and may be not considered in the assessment.

The following details used for assessment shall be described in the ETA (as far as relevant):

- Fulfilment of the requirements given in Table 2
- Anchor forces for load distribution to the adjacent parts of the nosing expansion joint shall be stated in the ETA.
- the load models
- adjustment factors
- load factors
- combination factors

2.2.1.1 Calculations

Models used for calculation shall take into account relevant boundary conditions (e.g. actions, operating temperature, opening of the joint).

The partial factors γ_M shall be determined either:

- in accordance with Clause 6.3 of EN 1990 and,
- where relevant, using the recommended values given in the relevant Eurocodes stated below, related to the materials.

In the ETA it shall be stated in terms of description that the product fulfils the mechanical resistance for the designs stated in the ETA and the partial factor γ_M values used for assessment shall be stated in the ETA.

Calculation of mechanical resistance, under the design situations stated in Annex D, Clause D.1, are following Eurocodes, in particular, those mentioned in Table 3:

- EN 1992-2
- EN 1993-1-4
- EN 1993-1-8
- EN 1993-1-10
- EN 1993-2
- EN 1994-2
- EN 1999-1-1
- EN 1999-1-4

Table 3: Guidance on assessment of mechanical resistance by calculation

Component	**Eurocode**	**Relevant clauses (exemplary)**
Edge beam	EN 1993-1-1	6.2.1
Anchorage system	EN 1992-1-1	6.5
Noise reducing elements	EN 1993-1-1	6.2.1

The loads shall be derived from Annex D, Clause D.2.

2.2.1.2 Testing

For assessment by means of testing Annex B, Clause B.8.2 applies.

The test specimen dimensions and the boundary conditions shall be selected in such a way that the structural behaviour complies with the behaviour in a real structure.

The loads shall be derived from Annex D, Clause D.2.

2.2.2 Resistance to fatigue

The nosing expansion joint shall have sufficient fatigue resistance with respect to its intended working life category according to Clause 1.2.2 in this EAD. The requirements given in Table 2 for ULS apply.

The actions, loads and combinations are given in Annex D, Clause D.2.

For the load distribution, the distribution given in Annex D, Figure D.2, with deviations defined in Clause 2.2.1 applies.

Where relevant due to the design, the dynamic response of the expansion joint, due to unevenness of their running surface and dynamic interaction such as upswing and damping, shall be considered.

For consideration of this aspect the amplification factor shall be taken as 1.

Resistance to fatigue shall be assessed by means of calculation and/or testing.

If assessment by calculation according to the methods given in Clause 2.2.2.1 is not possible (e.g. types 2c and d, Annex A), assessment shall be done by testing.

Where relevant (cantilevered load bearing elements), upswing effects shall be taken into account. The assessment of upswing effects shall be done in order to assess the concerned deflection and the related forces to be taken into account. The fatigue assessment shall be done with a fatigue load amplitude of +100 % and -30 % (this means a fatigue load interval of 1,3 times the fatigue load in Annex D, Clause D.2) of the load defined in Annex D, Clause D.2. The amplification factor $\Delta\varphi_{fat}$ = 1,3 and the values for consideration of upswing effects may be reduced based on dynamic testing (rollover test) according Annex C in this EAD.

Upswing U_v and U_h shall be considered by factored vertical loads for fatigue assessment according the following equations based on equations [D.5] and [D.6] in Annex D, Clause D.2.3.3.2:

$$Q_{1k,fat,mod} = \Delta\varphi_{fat} \times Q_{1k} \times 0{,}7 \times (1 + U_v)$$

$$Q_{1lk,fat,mod} = 0{,}2 \text{ x } \Delta\varphi_{fat,h} \text{ x } Q_{1k} \text{ x } 0{,}7 \times (1 + U_h)$$

The following details used for assessment shall be described in the ETA (as far as relevant):

- Fulfilment of the requirements given in Table 2
- Anchor forces for load distribution to the adjacent parts of the nosing expansion joint shall be stated in the ETA.
- the load models
- adjustment factors
- load factors
- combination factors

2.2.2.1 Calculations

The partial factors for fatigue shall be determined either:

- in accordance with Clause 6.3 of EN 1990 or,
- where relevant, using the recommended values given in the relevant Eurocodes stated below, related to the materials.

In the ETA it shall be stated in terms of description that the product fulfils resistance to fatigue for the designs stated in the ETA and the partial factor γ_M values used for assessment shall be stated in the ETA.

Models used for calculation shall take into account relevant boundary conditions (e.g. actions, operating temperature, opening of the joint).

Calculation of resistance to fatigue, under the design situations stated in Annex D, Clause D.2, are following Eurocodes, in particular, those mentioned in Table 4:

- EN 1992-2
- EN1993-1-9
- EN 1993-2
- EN 1994-2
- EN 1999-1-3

Table 4: Guidance on assessment of resistance to fatigue by calculation

Component	**Eurocode**	**Relevant clauses (exemplary)**
Edge beam	EN 1993-2	9.5.1
Anchorage system	EN 1992-1-1 / EN 1994-2	6.8.7 / 6.8
Noise reducing elements	EN 1993-2	9.5.1

Note: $\Delta\sigma_{E2}$ according EN 1993-2, clause 9.5.1 relates to number of cycles equal to 2,0 x 10^6, while loads given by Annex D.2.3.3.2 for fatigue load model $FLM1_{EJ}$ relate to number of cycles equal to 5,0 x 10^6. Therefore stresses $\Delta\sigma_{FLM1,EJ}$ resulting from loads according Annex D.2.3.3.2 for fatigue load model $FLM1_{EJ}$ have to be increased by a factor of 1,356 (equal to $1/(2/5)^{1/3}$) to reach the equivalence level of $\Delta\sigma_{E2}$ = 1,356 x $\Delta\sigma_{FLM1,EJ}$.

For fatigue detail classifications EN 1993-1-9, Clause 8, and EN 1993-2, Clause 9, apply.

For nosing expansion joints without traffic noise reducing elements only vertical actions and horizontal actions in the traffic direction, given in Annex D, Clause D.2, shall be assessed.

Therefore, depending on the design of the nosing expansion joint, the force parallel to the joint axis is considered to be transferred to the joint as a whole and may be not considered in the assessment.

2.2.2.2 Testing

The test specimen dimensions and the boundary conditions are selected in such a way that the structural behaviour complies with the behaviour in a real structure.

The loads shall be derived from Annex D, Clause D.2.

For the assessment the method given in Annex B applies.

For a transition strip, which is part of the kit, the following applies:

- if the transition strip is made of a mixture (as defined in EN ISO 472) based on a thermosetting binder the assessment method according to EN ISO 11357-2 shall be used, and the glass transition temperature shall be stated in the ETA as this is related to the plastic deformation expected in case it does not exceed the maximum operating temperature;
- if it is made of thermoplastics binder (as defined in EN ISO 472) the assessment method according to EN 12697-22 shall be used, considering the maximum operating temperature;
- if the transition strip is made of a bituminous mixture, the assessment method according EN 12697-22 shall be used, considering the maximum operating temperature.

For the second and third type of transition strip the resulting maximum deformation shall be stated in the ETA.

2.2.3 Seismic behaviour

The assessment of seismic behaviour is referred to the categories given in Annex D, Clause D.2.4.2.3.

Annex D, Table D.8 applies with the exception that the refitting of the sealing element for "expected repair work after earthquake" may be accepted for categories A2, B1 and B2.

The movement capacity of a nosing expansion joint including noise reducing elements does not allow movements in all directions, depending on the geometry of the noise reducing elements. The limitations of movements in all directions shall be assessed by analysis of the technical file and given in the ETA.

The seismic behaviour shall be assessed by analysis of the design of the expansion joint in relation to the categories given in Annex D, Clause D.2.4.2.3 using the principles for the total design value of the displacement (dealt with in Annex D, Clause D.2.4.2.3.2) in the seismic design situation according to EN 1998-2, Clause 2.3.6.3.

The assessed category and the relevant indications according to Annex D, Table D.8 shall be stated in the ETA.

2.2.4 Movement capacity

The movement capacity of an expansion joint is the possibility to allow the displacement of the parts of the main structure under unloaded and loaded conditions as given in Annex D, Clause D.2.

The movement capacity shall be assessed for 3 directions: longitudinal, transversal and vertical.

The movement capacity, including the minimum opening in closed position, may either be defined by the manufacturer or is an outcome of the assessment.

The influence of displacement velocity and the temperature is not relevant for products according to this EAD.

The movement capacity under unloaded conditions shall be assessed by testing. The test method is described in Annex D, Clause D.3.

For a sealing element without mechanical fixing in edge profiles ("compression seals"), the effect of creep and/or relaxation of the sealing element shall be considered by a pre-compression time of 24 h at the minimum opening before starting the test.

The results of the assessment of the movement capacity for the concerned directions shall be stated in the ETA. The reaction forces shall be stated in the ETA. The minimum opening shall be stated in the ETA.

2.2.5 Cleanability

The ability for self-cleanability shall be assessed based on the design of the nosing expansion joint or, if necessary, by an additional test in order to assess the contribution of the expansion joint opening and closing on it. This test is carried out in parallel to the testing procedure for assessment of movement capacity according to Annex D, Clause D.3, by depositing sand on the sealing element and assessing the removal of the sand under opening/closing movements of the joint.

For this purpose:

- During the 3rd and 4th cycles, addition of sand aggregate size of 2 mm (grading range 0 mm - 2 mm)
- At the end of the 6th cycle an opening corresponding to 120 % of the nominal opening is applied to assess the proper fixing and the mechanical resistance of the sealing element.

In case the nosing expansion joint does include optional component(s), e.g. traffic noise reducing elements, which lead to situation that the assessment method introduced above cannot be applied, the following applies: Cleanability is assessed by means of accessibility (e.g. dismountable noise reducing elements) to the relevant part of the nosing expansion joint (sealing element).

The proper functioning of the expansion joint shall not be affected by accumulation of debris, whereas the following results of assessment apply: Self-cleaning; Cleanable; Not cleanable.

Self-cleaning means the joint can be closed to the minimum opening position at the end of the test.

Cleanable means the joint cannot be closed to the minimum opening position at the end of the test, but the sand can be removed manually.

Not cleanable means it is neither self-cleaning nor it can be cleaned manually for all opening positions.

2.2.6 Watertightness

It shall be assessed whether the main structure and, where relevant, the sub-components of the nosing expansion joint under the running surface are protected from water and its chemical contents.

For the assessment of the watertightness of the nosing expansion joint, the test method is described in Annex D, Clause D.4.

For the test method according to Annex D, Clause D.4, the value of opening used for testing is defined by the worst condition which is the minimum contact pressure between the sealing element and the edge profiles.

For a sealing element without mechanical fixing in edge profiles ("compression seals") the effect of creep and/or relaxation of the sealing element shall be considered by a pre-compression time of 24 h at the minimum opening before starting the test.

The result of the assessment of the watertightness (moisture under the joint) shall be stated in the ETA, whereas the following results of assessment apply: Watertight; Not watertight.

In addition:

Where a watertight connection between the waterproofing system of the main structure and the nosing expansion joint is foreseen as component of the expansion joint, for the assessment according to Annex D, the last paragraph in Clause D.4.4.1 applies in addition.

The type of the connection shall be described in the ETA.

The result of the assessment of the watertightness (moisture under the joint) shall be stated in the ETA, whereas the following results of assessment apply: Watertight; Not watertight.

2.2.7 Durability

2.2.7.1 Corrosion

For metallic surfaces of components the climatic classification in accordance with EN ISO 9223 (see Clause 1.1) with respect to the intended use of the product is taken into account.

It shall be assessed whether the corrosion protection layout for the concerned kit conforms with the scope of the EAD (possibly using the technical documentation of the manufacturer).

Galvanic corrosion is not assessed.

Based on the manufacturer's technical documentation for the corrosion protection system the durability class in relation to the corrosivity class according to the standards given in Clause 1.1 shall be given in the ETA.

2.2.7.2 Chemicals

Assessment of the resistance to de-icing salts of the components made of elastomer shall be done according to ISO 1817 (immersion for 14 days 23 °C, 4 % sodium- chloride solution or equivalent).

The components made of elastomer shall show no decrease of hardness exceeding 5 Points and no increase of volume exceeding 10 %.

2.2.7.3 Loss of performance due to ageing resulting from temperature and ozone

The performance of the nosing expansion joint shall not be affected by ageing. For the product according to this EAD this applies to the components made of elastomer.

2.2.7.3.1 Resistance to ageing resulting from temperature

To assess the sensitivity of the components made of elastomer to elevated temperature, the material shall be subjected to test method ISO 188 (Method A). The minimal conditions of exposure are the following: 14 days at a temperature of 70 °C.

The hardness before and after ageing is measured according to ISO 48-2 or ISO 48-4 respectively, the tensile strength and the elongation at break are measured according to ISO 37.

After ageing, the change in hardness and the change of tensile properties of the aged specimen shall be within:

Hardness ≤ + 7 points

Tensile strength ≥ -20%

Elongation at break ≥ -30%

These values apply for all working life categories.

For the assessment of the resistance of the components made of elastomer to low temperatures, the brittleness test according to ISO 812, Method B applies.

With respect to the operating temperature condition, according to Clause 1.2.1, for the execution of the brittleness test the following temperatures apply:

-25 °C for operating temperatures down to -20 °C,

-40 °C for operating temperature equal to -30 °C,

-55 °C for operating temperature equal to -40 °C.

2.2.7.3.2 Resistance to ageing resulting from ozone

To assess the sensitivity of the components made of elastomer to ozone, the material shall undergo a test. The test specimen shall be assessed according to test method ISO 1431-1 (Test procedure A: static condition).

The test conditions are the following: 72 hours of exposure at the temperature of 40 °C, with an ozone concentration of 50 pphm. The test specimen is submitted to 20 % of elongation.

After the test no cracks shall occur.

2.2.7.3.3 Resistance against freeze thaw

If relevant, the degradation of porous materials (e.g. mortar), to freeze-thaw shall be assessed by testing. Test specimen(s) of the material or component shall be subjected to freeze/thaw cycles in accordance with EN 13687-1. According to the use of the product, the number of cycles shall be 50 (see EN 1504-2, Tables 5, line 9 and Table 1, 1.3 and 5.1).

After the test, no degradation shall be observed.

2.2.8 Content, emission and/or release of dangerous substances

The performance of the product related to the emissions and/or release and, where appropriate, the content of dangerous substances will be assessed on the basis of the information provided by the manufacturer[3] after identifying the release scenarios (in accordance with EOTA TR 034) taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market.

The identified intended release scenario for this product and intended use with respect to dangerous substances is:

S/W2: Product with indirect contact to soil, ground- and surface water

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[3] The manufacturer may be asked to provide to the TAB the REACH related information which he must accompany the DoP with (cf. Article 6(5) of Regulation (EU) No 305/2011).

The manufacturer is **not** obliged:
- to provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
- to provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS.

Any information provided by the manufacturer regarding the chemical composition of the products may not be distributed to EOTA or to TABs.

2.2.8.1 Leachable substances

For the intended use covered by the release scenario S/W2 the performance of the components made of elastomer concerning leachable substances has to be assessed. A leaching test with subsequent eluate analysis must take place, each in duplicate. For the leaching tests of the sealing element Annex D, Clause D.6 applies.

2.2.9 Ability to bridge gaps and levels in the running surface

2.2.9.1 Allowable surface gaps and voids

The maximum dimensions of the gaps and voids of the joint at the surface level depend on the three user categories.

For the range of the skew angle β (see Figure 2) to be assessed for all user categories the following requirements shall be met and the chosen approach according to Clause 1.3.12 shall be stated in the ETA.

For vehicles and cyclists categories the expansion joint shall not allow a vertical displacement of more than the radius of a 10,0 cm diameter sphere placed anywhere on the running surface level.

a) Vehicles

The expansion joint shall not allow a vertical displacement of 1,0 cm or more of the following bodies, in conjunction with the traffic direction:

- a horizontal prism with plan dimensions 10,0 cm by 20,0 cm placed horizontally anywhere and in any direction,
- a horizontal prism with plan dimensions 6,5 cm by 22,0 cm placed horizontally anywhere with a deviation from the traffic direction α of -20° to +20°,
- a horizontal prism with plan dimensions 4,5 cm by 35,0 cm placed horizontally anywhere with a deviation from the traffic direction α of -20° to +20°.

b) Cyclists

The expansion joint shall not allow a vertical displacement of 1,0 cm or more of the following bodies, in conjunction with the traffic direction:

- a horizontal prism with plan dimensions 2,0 cm by 22,0 cm placed horizontally everywhere with a deviation from the traffic direction α of -20° to +20°,
- a horizontal prism with plan dimensions 10,0 cm by 20,0 cm placed horizontally everywhere and in any direction.

The design of the expansion joint for the carriageway can be adapted by special measures to fulfil the above requirement (see Clause 1.1).

c) Pedestrians

The expansion joint shall not allow a vertical displacement of 2,0 cm or more of a disk with a diameter of 8,0 cm placed horizontally everywhere.

Assessment shall be carried out by analysis of the technical file and, when needed, by use of measurements tools given above.

The ETA shall state the maximum skew angle β (relative to the traffic direction) in relation to the maximum opening related to the concerned user category.

The definition of the skew angle used for the assessment shall be stated in the ETA (see Clause 1.3.12 for different possibilities).

The design of the expansion joint for the carriageway can be adapted by special measures to fulfil the above requirement (see Clause 1.1).

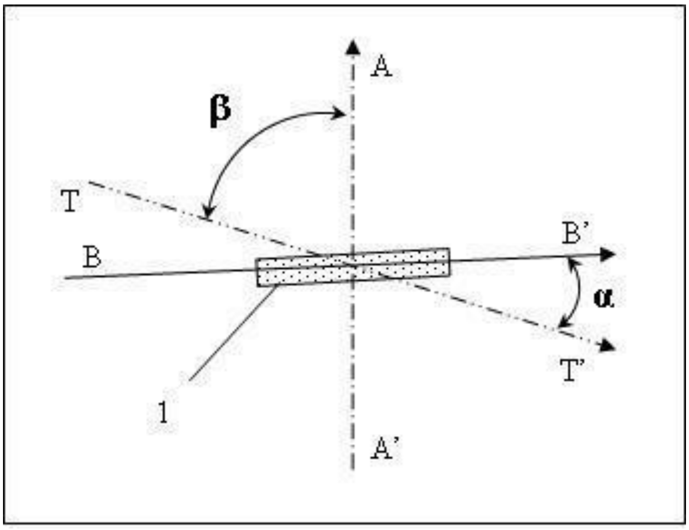


Figure 2: Assessment of the allowable gaps and voids

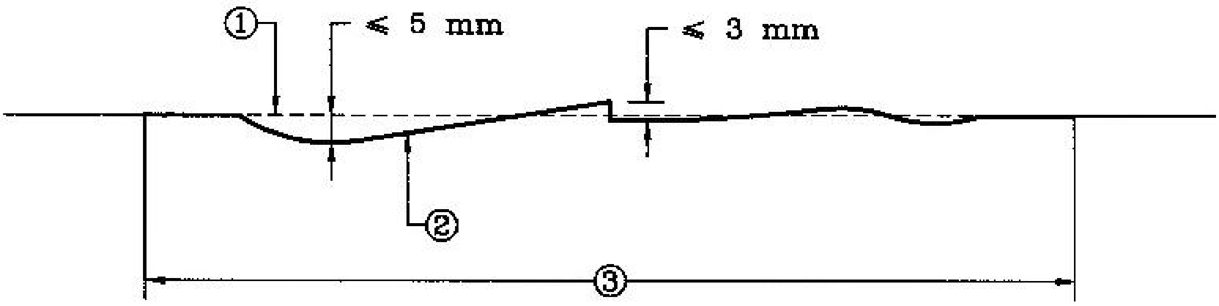
Key to Figure 2:

TT': Traffic direction
AA': Expansion joint axis
BB': Orientation of the measuring prism
1: Measuring prism
α: Deviation from traffic direction
β: Skew angle

2.2.9.2 Level differences in the running surface

Without any imposed horizontal deformations and in unloaded condition the difference in the levels of the running surface of the joint from the ideal connection line between the two adjacent pavements in the traffic direction shall not be greater than 5 mm. Steps shall not be greater than 3 mm (without considering surface texture and discontinuities due to gaps and voids). See Figure 3.

This rule is applied in a horizontal position.



① Ideal connection line
② Running surface of the joint
③ Expansion joint
Note: The level differences could be in the opposite direction.

Figure 3: Example of level differences in the running surface under unloaded conditions

Where a transition strip is part of the product, the relative slope of the line between the adjacent surfacing and the metal runner profile in the direction of the traffic shall not be greater than 2 %. See Figure 4. In case of nosing expansion joint without transition strip, the value of slope is not relevant.

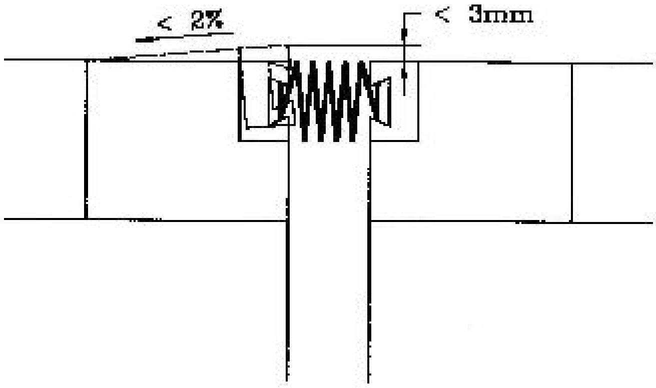


Figure 4: Level differences in the area of transition strip (if part of the kit)

Assessment for the unloaded condition shall be undertaken on the basis of analysis of the technical file and drawings. The maximum dimension of steps and the difference of the running surface levels shall be stated in the ETA.

Loaded condition:

The deformation under SLS loading condition according to Annex D, Clause D.2 is assessed by calculation or, following the conditions stated in Clause 2.2.2 in this EAD, by testing according to Annex B, Clause B.8.2.

Level differences shall not be more than the value observed during resistance to fatigue testing according to Annex B, Clause B.8.2 in the case of static loading and calculation according to Clause 2.2.1 respectively and not more than 12 mm in total.

Under loaded conditions, the maximum vertical deflection, according to the assessment by testing or calculation, shall be stated in the ETA.

2.2.10 Skid resistance

This essential characteristic only applies for nosing expansion joints with flat running surfaces larger than 150 mm x 150 mm square and with surface textures less than ± 1,2 mm (possibly met by special design, e.g. chequered plate). This applies to the carriageway and footpath.

The skid resistance of the nosing expansion joint shall be assessed by the portable skid resistance pendulum tester as described in EN 13036-4, clause 9.2 using the 57 Rubber slider for carriageways and the 96 rubber slider for footpaths. For both, the normal slider width of 76.2 mm shall be used.

The PTV values assessed shall be stated in the ETA.

2.2.11 Drainage capacity

Where relevant due to the nosing expansion joint kit is including a drainage device, the drainage capacity shall be assessed according to the assessment method described in Annex D, Clause D.5.

The drainage capacity in mm^3/sec together with definition of the porous pavement as defined according to the assessment method in Annex D, Clause D.5, shall be stated in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: Decision 2001/19/EC

The system is: 1

The performance of any kit component which is obtained from a component manufacturer and is CE marked on the basis of a hEN or an EAD will, (for the purposes of verification of constancy of performance) be considered to be the performance declared by the component manufacturer in his DoP. The component does not need to be re-assessed regarding this performance aspect.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the kit in the procedure of assessment and verification of constancy of performance are laid down in Table 5a.

The actions to be undertaken by the manufacturer of the kit are laid down in Table 5b when the components are produced by the manufacturer himself and Table 5c when the components are not produced by the manufacturer himself but by his supplier under the specifications of the manufacturer.

Table 5a Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC)					
1	Components produced by the manufacturer himself :				
	▪ Components made of elastomer	See Table 5b, No1	See Table 5b, No1	See Table 5b, No1	See Table 5b, No1
	▪ Components made of steel/stainless steel	See Table 5b, No2	See Table 5b, No2	See Table 5b, No2	See Table 5b, No2
	▪ Components made of cast iron and/or cast steel	See Table 5b, No3	See Table 5b, No3	See Table 5b, No3	See Table 5b, No3
	▪ Components made of aluminium alloy	See Table 5b, No4	See Table 5b, No4	See Table 5b, No4	See Table 5b, No4
	▪ Other components	See Table 5b, No5	See Table 5b, No5	See Table 5b, No5	See Table 5b, No5
2	Components not produced by the manufacturer himself (*)	See Table 5c	See Table 5c	See Table 5c	See Table 5c
3	Kit	See Table 5d	See Table 5d	See Table 5d	See Table 5d
(*) Components produced by the supplier under the specifications of the manufacturer.					

Table 5b Control plan when the components are produced by the manufacturer himself; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
Factory production control (FPC) including testing of samples taken at the factory in accordance with a prescribed test plan					
1	**Components made of elastomer**		Laid down in the control plan	According to the relevant standard.	Each lot or each delivery.
1.1	Density	ISO 2781			
1.2	Hardness	ISO 48-2 or ISO 48-4			
1.3	Tensile strength	ISO 37			
1.4	Elongation at break	ISO 37			
1.5	Tear resistance	ISO 34-1			Every three months.
1.6	Compression set	ISO 815-1 24 h and 70 °C constant deflexion 25 %			Once per year.
1.7	Thermogravimetric analysis (TGA)	ISO 9924-1 or ISO 9924-3			Once per year.
Parameters 1.1-1.7 for the **components made of elastomer** are related to the essential characteristics 1, 2, 3, 4, 5, 6, 7, 8 and 10 in Table 1 of this EAD for the nosing expansion joint kit.					

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
2	**Components made of steel/stainless steel**	EN 10025 (relevant part laid down in control plan) or EN 10088 (relevant part laid down in control plan)	Laid down in the control plan	According to the relevant standard.	Each delivery.
2.1	Elasticity limit $f_{0,2k}$ at 0,2 %				
2.2	Tensile strength				
2.3	Elongation at break				
2.4	Energy absorption (Charpy V test) (if dynamically loaded)				
2.5	Chemical composition				
2.6	Corrosion protection: - Assessment of the thickness and the continuity of the layer - Surface characteristics before corrosion protection application (roughness, cleanliness) - Drying time	Laid down in the control plan			Each batch or every assembled expansion joint.
Parameters 2.1-2.6 for the **components made of steel/stainless steel** are related to the essential characteristics 1, 2, 3, 7 and 10 in Table 1 of this EAD for the nosing expansion joint kit.					
3	**Components made of cast iron and/or cast steel**	ISO 1083	Laid down in the control plan	According to the relevant standard.	Each delivery.
3.1	Elasticity limit $f_{0,2k}$ at 0,2 %				
3.2	Tensile strength				
3.3	Elongation at break				
3.4	Hardness Vickers				
3.5	Energy absorption (Charpy V test) (if dynamically loaded)				
3.6	Chemical composition				
3.7	Corrosion protection: - Assessment of the thickness and the continuity of the layer - Surface characteristics before corrosion protection application (roughness, cleanliness) - Drying time	Laid down in the control plan			Each batch or every assembled expansion joint
Parameters 3.1-3.7 for the **components made of cast iron and/or cast steel** are related to the essential characteristics 1, 2, 3, 7 and 10 in Table 1 of this EAD for the nosing expansion joint kit.					

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
4	**Components made of aluminium alloy**	EN 755-2 or EN 485-2	Laid down in the control plan	According to the relevant standard.	Each delivery.
4.1	Chemical composition				
4.2	Elasticity limit at 0,2 %				
4.3	Tensile strength				
4.4	Elongation at break				
Parameters 4.1-4.4 for the **components made of aluminium alloy** are related to the essential characteristics 1, 2, 3, 7 and 10 in Table 1 of this EAD for the nosing expansion joint kit.					
5	**Other components** Relevant parameters are laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan
Parameters for the **other components** are related to the essential characteristics in Table 1 of this EAD for the nosing expansion joint kit according to their use in the kit.					

*) In case of irregular production it is possible to agree different frequency between manufacturer and notified body.

Table 5c: Control plan when the components are not produced by the manufacturer; cornerstones.

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC)					
1	Components belonging to Case 1 (*)	(1)	Conformity with the order	Testing is not required	Each delivery
		(2)	Acc. to Control Plan	Testing is not required	Each delivery
2	Components belonging to Case 2 (**):	(1)	Conformity with the order	Testing is not required	Each delivery
	▪ Characteristics declared in DoP for the specific use within the kit.	(2)	Acc. to Control Plan	Testing is not required	Each delivery
	▪ Characteristics not declared in DoP for the specific use within the kit.	(3)	Acc. to Control Plan	Acc. to Control Plan	Acc. to Control Plan
3	Components belonging to Case 3 (***):	(1)	Conformity with the order	Testing is not required	Each delivery
		(3)	Acc. to Control Plan	Acc. to Control Plan	Acc. to Control Plan

(1) Checking of delivery ticket and/or label on the package.
(2) Checking of technical data sheet and DoP or, when relevant: supplier certificates or supplier tests or test or control acc. to Table 5b above.
(3) Checking of supplier documents and/or supplier tests and/or test or control acc. to Table 5b above.
(*) Case 1: Component covered by a hEN or its own ETA for all characteristics needed for the specific use within the kit.
(**) Case 2: If the component is a product covered by a hEN or its own ETA which, however, does not include all characteristics needed for the specific use within the kit or the characteristic is presented as NPD option for the component manufacturer.
(***) Case 3: The component is a product not (yet) covered by a hEN or its own ETA.

Table 5d: Control plan of the complete kit; cornerstones.

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC)					
1	Conformity to the specification drawings e.g. preset, corrosion protection, correct elements, dimensions, pre assembly.	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each assembled product.

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for nosing expansion joints for road bridges are laid down in Table 6.

The performance of the components covered by hTSs regarding those characteristics declared already by the component manufacturers in their DoP should not be assessed when the product (the kit) will be assessed by the TAB. The performance of those components for the purpose of issuing the ETA will be considered to be the performance declared by the manufacturers of the component. TABs may only assess the performance of the components only for essential characteristics not declared by the manufacturer of the component in his DoP.

Table 6 Control plan for the notified body; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the expansion joint.	As defined in the control plan.	As defined in the control plan.	As defined in the control plan.	1
Continuous surveillance, assessment and evaluation of factory production control					
2	Continuous surveillance, assessment and evaluation of factory production control carried out by the manufacturer (parameters according to Tables 5a to 5d of this EAD).	As defined in the control plan.	As defined in the control plan.	As defined in the control plan.	At least once a year

4 REFERENCE DOCUMENTS

EN 485-2:2016+A1:2018	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
EN 755-2:2016	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 2: Mechanical properties
EN 1504-2:2004	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 2: Surface protection systems for concrete
EN 1990:2002 + A1:2005 + A1:2005/AC:2010	Eurocode: Basis of structural design
EN 1991-1-5:2003 + AC:2009	Eurocode 1: Actions on structures - Part 1-5: General actions - Thermal actions
EN 1991-2:2003 + AC:2010	Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges
EN 1992-1-1:2004 + AC:2010	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
EN 1992-2:2005 + AC:2008	Eurocode 2: Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules
EN 1993-1-1:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
EN 1993-1-4:2006 + A1:2015	Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
EN 1993-1-8:2005 + AC:2009	Eurocode 3: Design of steel structures — Part 1-8: Design of joints
EN 1993-1-9:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-9: Fatigue
EN 1993-1-10:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
EN 1993-2:2006 + AC:2009	Eurocode 3: Design of steel structures - Part 2: Steel Bridges
EN 1994-2:2005 + AC:2008	Eurocode 4: Design of composite steel and concrete structures — Part 2: General rules and rules for bridges
EN 1998-2:2005 + A1:2009 + A2:2011 + AC:2010	Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges
EN 1999-1-1:2007 + A1:2009 + A2:2013	Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules
EN 1999-1-3:2007 + A1:2011	Eurocode 9: Design of aluminium structures — Part 1-3: Structures susceptible to fatigue
EN 1999-1-4:2007 + AC:2009	Eurocode 9: Design of aluminium structures — Part 1-4: Cold-formed structural sheeting
EN 10025-2:2004	Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
EN 10025-3:2004	Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels

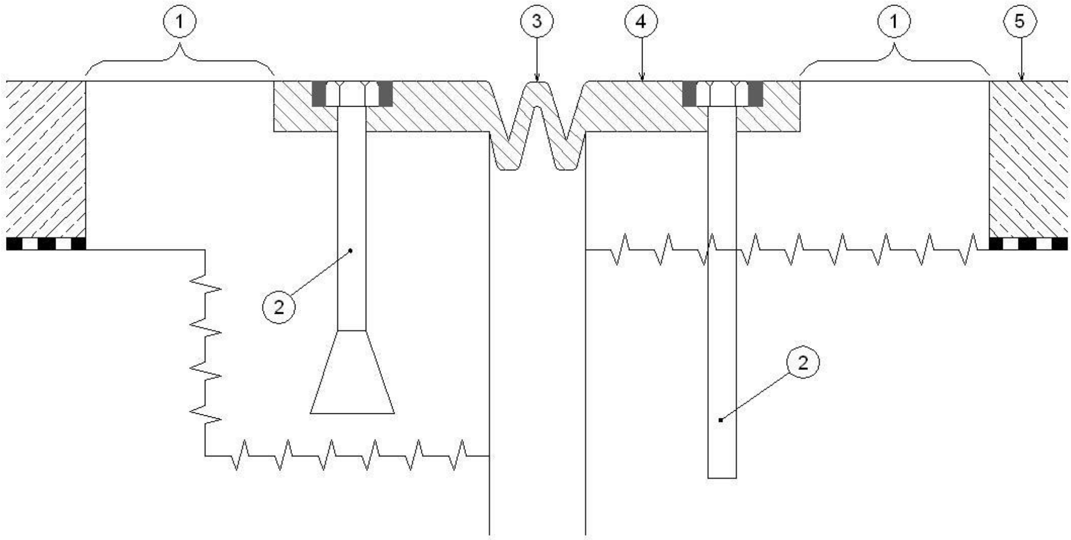
EN 10025-4:2004	Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
EN 10025-5:2004	Hot rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
EN 10025-6:2004 + A1:2009	Hot rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
EN 10088-2:2014	Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes
EN 10088-3:2014	Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes
EN 10088-4:2009	Stainless steels - Part 4: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
EN 10088-5:2009	Stainless steels - Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes
EN 12697-22:2003 + A1:2007	Bituminous mixtures - Test methods for hot mix asphalt - Part 22: Wheel tracking
EN 13036-4:2011	Road and airfield surface characteristics - Test methods - Part 4: Method for measurement of slip/skid resistance of a surface - The pendulum test
EN 13687-1:2002	Products and systems for the protection and repair of concrete structures - Test methods; Determination of thermal compatibility - Part 1: Freeze-thaw cycling with de-icing salt immersion
EN ISO 472:2013	Plastics - Vocabulary
EN ISO 2081:2018	Metallic and other inorganic coatings - Electroplated coatings of zinc with supplementary treatments on iron or steel
EN ISO 3506-1:2009	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs
EN ISO 6341:2012	Water quality - Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) - Acute toxicity test
EN ISO 9223:2012	Corrosion of metals and alloys - Corrosivity of atmospheres - Classification, determination and estimation
EN ISO 10684:2004 + AC:2009	Fasteners - Hot dip galvanized coatings
EN ISO 11348-1:2008	Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test) - Part 1: Method using freshly prepared bacteria
EN ISO 11348-2:2008	Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test) - Part 2: Method using liquid-dried bacteria
EN ISO 11348-3:2008	Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test) - Part 3: Method using freeze-dried bacteria
EN ISO 11357-2:2014	Plastics - Differential scanning calorimetry (DSC) - Part 2: Determination of glass transition temperature and glass transition step height
EN ISO 12944-1:2017	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction

EN ISO 14713-1:2017	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 1: General principles of design and corrosion resistance
ISO 34-1:2015	Rubber, vulcanized or thermoplastic - Determination of tear strength - Part 1: Trouser, angle and crescent test pieces
ISO 37:2017	Rubber, vulcanized or thermoplastic - Determination of tensile stress-strain properties
ISO 48-2:2018	Rubber, vulcanized or thermoplastic - Determination of hardness - Part 2: Hardness between 10 IRHD and 100 IRHD
ISO 48-4:2018	Rubber, vulcanized or thermoplastic - Determination of hardness - Part 4: Indentation hardness by durometer method (Shore hardness)
ISO 188:2011	Rubber, vulcanized or thermoplastic - Accelerated ageing and heat resistance tests
ISO 812:2017	Rubber, vulcanized or thermoplastic - Determination of low-temperature brittleness
ISO 815-1:2014	Rubber, vulcanized or thermoplastic - Determination of compression set - Part 1: At ambient or elevated temperatures
ISO 1083:2018	Spheroidal graphite cast irons - Classification
ISO 1431-1:2012	Rubber, vulcanized or thermoplastic - Resistance to ozone cracking - Part 1: Static and dynamic strain testing
ISO 1817:2015	Rubber, vulcanized or thermoplastic - Determination of the effect of liquids
ISO 2781:2018	Rubber, vulcanized or thermoplastic - Determination of density
ISO 9924-1:2016	Rubber and rubber products - Determination of the composition of vulcanizates and uncured compounds by thermogravimetry - Part 1: Butadiene, ethylene-propylene copolymer and terpolymer, isobutene-isoprene, isoprene and styrene-butadiene rubbers
ISO 9924-3:2009	Rubber and rubber products - Determination of the composition of vulcanizates and uncured compounds by thermogravimetry - Part 3: Hydrocarbon rubbers, halogenated rubbers and polysiloxane rubbers after extraction
ISO 15799:2003	Soil quality - Guidance on the ecotoxicological characterization of soils and soil materials
CEN/TS 16637-2:2014	Construction products - Assessment of release of dangerous substances - Part 2: Horizontal dynamic surface leaching test
OECD Test Guideline 301 Part A:1992	OECD Guideline for testing of chemicals – Ready Biodegradability - Part A - DOC Die-Away
OECD Test Guideline 301 Part B:1992	OECD Guideline for testing of chemicals – Ready Biodegradability - Part B - CO_2 Evolution (Modified Sturm Test)
OECD Test Guideline 301 Part E:1992	OECD Guideline for testing of chemicals – Ready Biodegradability - Part C - Modified OECD Screening
EOTA TR034	General BWR3 Checklist for EADs/ETAs - Dangerous substances

ANNEX A – DIFFERENT TYPES OF NOSING EXPANSION JOINTS

The purpose of this Annex is to illustrate exemplary different types of products which are covered by this EAD.

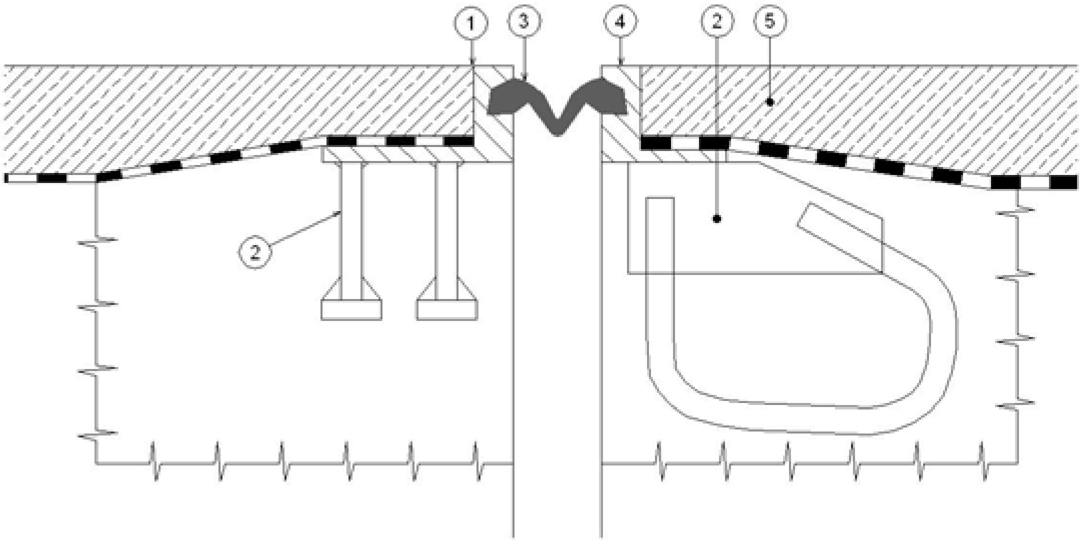
Type 1 the sealing element is held in place with anchorages



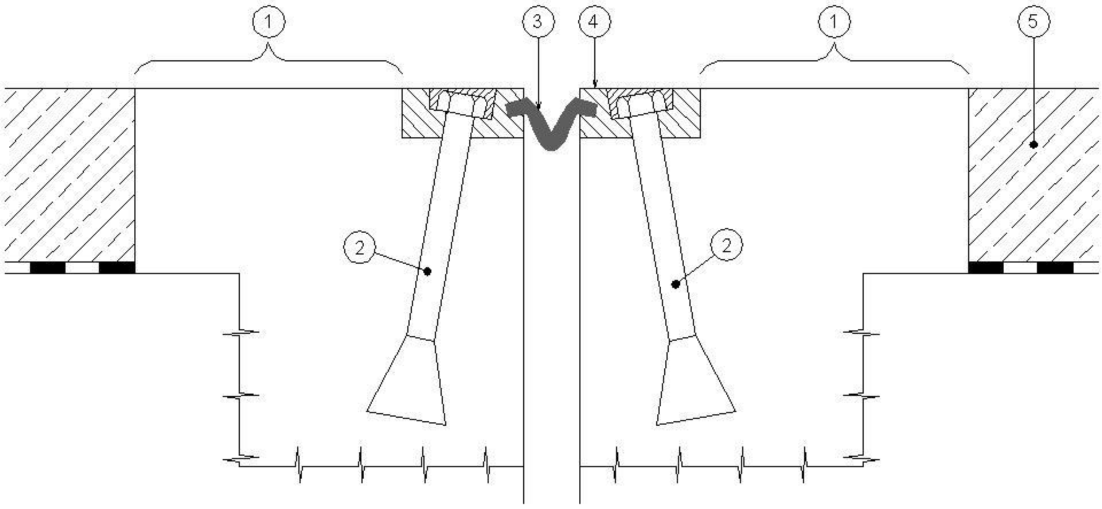
Type 2 the sealing element is held in place by clamping and/or adhesive or compression. The clamp to maintain the sealing element is generally in metal but it is possible to have this clamp in resin mortar or other material.

In this sub family the connection to the structure is made by:

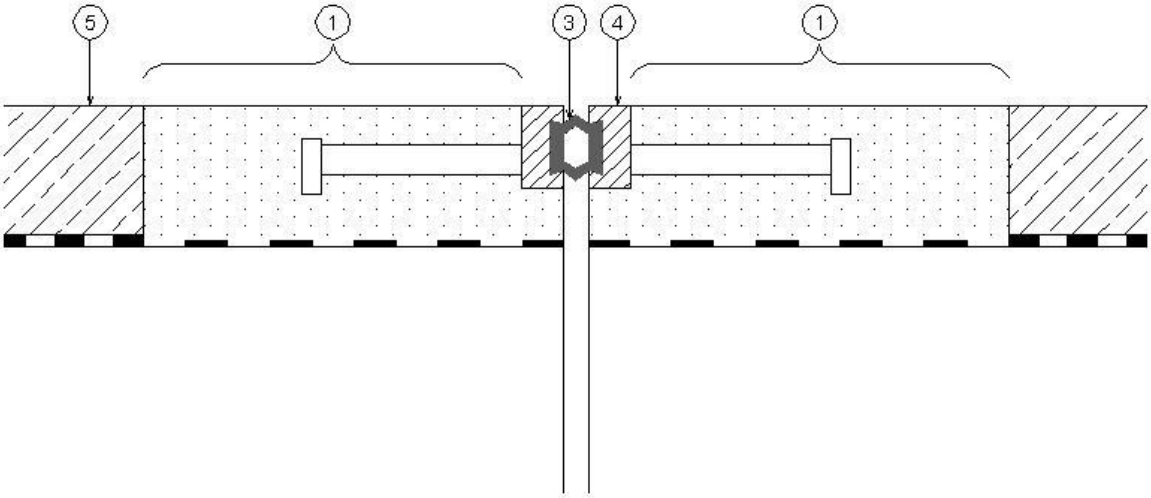
a) Reinforcement



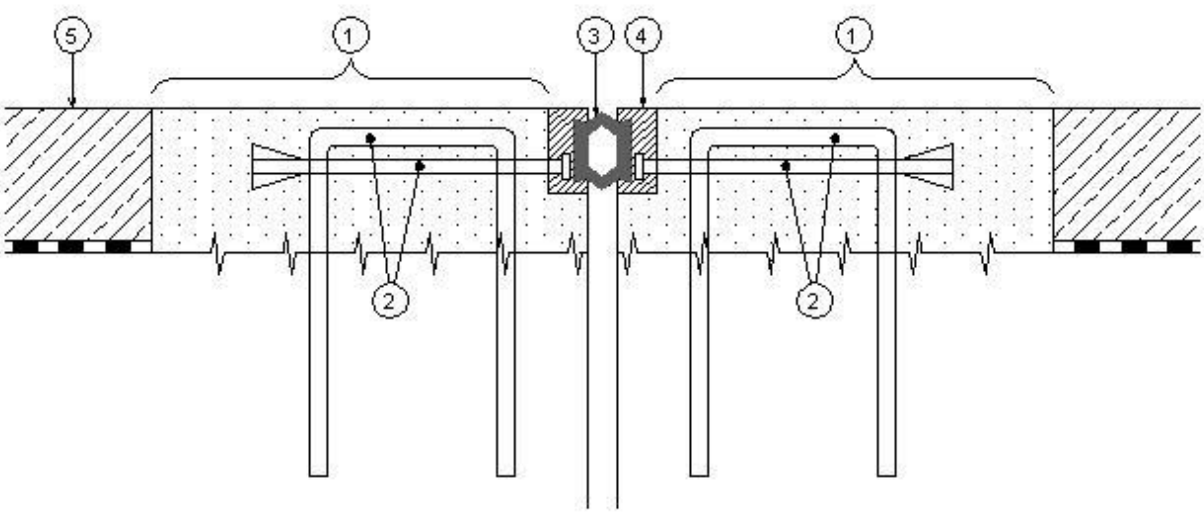
b) Screw and dowels or bolts



c) Adhesion to the bridge deck concrete



d) A combination of adhesion to the bridge deck concrete completed by fastening of reinforcement into holes



Key

1 – Transition strip: material between the expansion joint and the adjacent surfacing. Three types of transition strip can be distinguished:

1.1 – According to the method of installation of the product, the transition strip is made by a concrete beam connected to the structure and on which the expansion joint is applied. It is not supplied as part of the product (see Figure type 1 or 2b, for example).

1.2 – According to the method of installation of the product, the transition strip is a sealing product spread against the metal profile with the purpose of avoiding a crack between surfacing and expansion joint to reduce the risk of water penetration between the interface of the expansion joint and carriageway (see Figure type 2a).

1.3 – According to the design of the product, the transition strip is an intermediate beam on which the expansion joint is totally or partially connected and this beam is thereafter, connected to the structure. This transition material is part of the product (see Figure type 2c or 2d, for example).

For the two first examples, the type of transition strip is independent of the product and it is defined in the ETA based on technical documentation provided by the manufacturer.

2 – Anchorage system: Bars and rods that connect the expansion joint to the main structure or the abutment with examples for types of anchorage systems.

3 – Sealing element

4 – Edge profiles

The keys 1.3, 2, 3 and 4 are a part of the product.

5 – Surfacing
Not part of the assessment.

ANNEX B – ASSESSMENT OF RESISTANCE TO FATIGUE BY TESTING

FOREWORD

This annex provides the conditions for and execution of assessment of resistance of fatigue by means of testing. It may also be used in case certain components may be assessed by testing.

B.1 – SCOPE

This annex describes the assessment of resistance to fatigue by means of full scale laboratory testing.

This test also includes the assessment of vertical deflection under static loading conditions.

B.2 – TERMS AND DEFINITIONS

For the purposes of this annex, terms and definitions given in Clause 1.3 and the following apply.

B.2.1 Movement

Variation of the relative displacement between the parts of the structure supporting the expansion joint.

B.2.2 Cycle

A cycle corresponds to a phase of one period of loading and unloading of the element tested.

B.3 – PRINCIPLE

The principle of this test procedure is to apply a simulation of the traffic loads. These conditions are considered to represent the design situations.

For this purpose, a suitable device applies an action effect representing the fatigue loads on a specimen of the product. This device shall apply, with a number of cycles, a vertical force in conjunction with a horizontal force which is obtained by a resultant force with an appropriate angle.

The test is carried out in a laboratory on a standard section of the nosing expansion joint scale one to one.

One specimen of each type has to be tested.

If there is a range with the same type, then take one test at each border of the range and one test in the middle of the range.

The test is performed on an expansion joint kit. However, if no important interactions among the functions of the various elements occur, tests on a relevant part of the kit can be made using the same approach.

Note: In such case the actual behaviour of the expansion joint should be assessed by means of calculations and data on the connections and interactions among the various elements.

One (or several) element(s) of an expansion joint is (are) installed on support beams with or without recess in conformity with the manufacturer's Installation Manual. These mobile blocks support allow the adjustment of the opening of the joint at the values defined for the test.

B.4 – TRAFFIC LOADS AND NUMBER OF CYCLES

The test loads shall be derived from $FLM1_{EJ}$ and/or $FML2_{EJ}$ in accordance with Annex D, Clause D.2. According to this, an example related to N_{obs} = 0,5 million/year is given in Annex F, Table F.3.

For the principles for the number of cycles and related conditions, Annex F applies.

B.5 – TESTING CONDITIONS

The test load shall be derived from B.4 and distributed according to Annex D, Clause D.2. It shall be applied with an angle according to the vertical and horizontal load ratio given in Annex D, Clause D.2 in the direction of the expansion joint gap.

The test is carried out under the following conditions:

- Test temperature:

  The ambient temperature during the test shall lie between +5 °C and +30 °C. These conditions cover all operating temperatures.

- Number of load cycles:

  The number of load cycles is determined according to the specified categories of working life (see Clause 1.2.2 and B.4).

- Positioning of the specimen:

  The test shall be carried out at 60 % of the maximum opening position. The relative positioning of the travelling loads on the specimen shall be the most unfavourable loading condition.

- Frequency:

  The frequency shall be equal or greater than 0,5 Hz.

B.6 – EQUIPMENT

The support of the test specimen shall simulate realistic support conditions, including anchorage.

The test rig shall be able to control the tolerance on the forces within deviations of ±5 % and shall include a suitable device for counting the number of cycles.

The test arrangement shall not influence the test result by resonance effects. A dynamic analysis of the test arrangement shall show that no resonance effects are to be expected.

The actuators shall be calibrated and the actuating system shall not cause inaccuracies in the measurements.

Devices for counting the number of cycles shall be adapted to the maximum frequency of the test while allowing the recording of the data of the test.

The measuring tolerances on load shall be ±1 kN.

B.7 – SPECIMEN AND PREPARATION OF TEST

The expansion joint kit to be tested consists at least of a current section of the product with 1,2 m length. If relevant, it shall comprise at least one standard connection (butt joint). The exact length of the specimen is fixed by agreement between the manufacturer, the Technical Assessment Body and the test laboratory according to the type of product in order to avoid cuts modifying the operating mode.

For testing of part of the kit (see B.3), the same approach applies except the minimum length of 1,2 m.

A detailed description of the test specimen (including specification of the kit and its components and including tolerances) is to be provided and included in the test report.

The preparation of the test specimen is under the responsibility of the manufacturer.

B.8 – EXECUTION OF THE TEST

B.8.1 Test procedure

a) Before the test:

- Check the fastenings of the joint, its opening and the level of its surface.
- Apply and check the maximum load and its direction using a calibrated device.

b) For the test, the load is applied by fully reversed cycles (means complete de-loading before applying the load again) as defined in B.5.

c) During the test, at the stages corresponding to 10 000, 100 000 and every 500 000 load cycles and at the end of test:

- Record by visual inspection the behaviour of the joint.
- Record the appearance of any disorder (e.g. cracking of the sealing element, defect of fixing of the sealing element in its groove, plastic deformations, failure of welding, …).

B.8.2 Assessment of static deflection

To assess mechanical resistance at SLS and related deflection for level differences in the running surface (Clause 2.2.9.2), the test is carried out before fatigue test with the load on the expansion joint.

This test is done after the procedure described in B.8.1 a).

B.9 – EXPRESSION OF RESULTS

Displacements and the value of movement capacity are expressed in mm and forces are expressed in kN.

Information to be given will fit in one of the following proposals:

1) The product tested does not present any disorder, or minor disorders such as wear, ...,

2) The product tested presents major disorders such as failure, non-reversible deformation (greater than 0,5 mm in all direction), failure of welding, ...

The observation on the product after test shall be linked with requirements in Table 2 in this EAD.

A precise localisation of the disorders as well as photographs and statements shall be attached to the report.

B.10 – TEST REPORT

B.10.1 Test report for fatigue assessment

The test report shall refer to the present annex and mention at least:

- The origin of the expansion joint to be tested (the name of the manufacturer, the name of the production centre);
- The model identification (type, theoretical movement capacity, N° of batch);
- Description of the test equipment, the consistency of the assessment with how the criteria and guidance of this annex are respected;
- The date of the preparation of specimens, the date of test and the test mean temperature;
- The statement of principal dimensions and characteristics which allow for unique identification of the product tested;
- Observations on the behaviour corresponding to each stage, non-reversible deformation value which can be detected, …;

B.10.2 Test report for assessment of deformation under static load

The test report shall refer to the present annex and mention at least:

- The origin of the expansion joint to be tested (the name of the manufacturer, the name of the production centre);
- The model identification (type, theoretical movement capacity, N° of batch);
- Description of the test equipment;
- The date of the preparation of specimens, the date of test and the test mean temperature;
- The statement of principal dimensions and characteristics which allow for unique identification of the product tested;
- Brief description of the test conditions;
- Value and location of the measurement;

ANNEX C – DYNAMIC ASSESSMENT AND FIELD TESTING

C.1 Introduction

A expansion joint is a kit, assembled from components. In addition field-testing allows the determination of the dynamic behaviour of the kit or single components of joints.

This annex describes how field tests of the kit shall be arranged and carried out and how the dynamic behaviour can be evaluated. Here, field-testing means that tests are carried out on full-scale joints which can be situated in an existing road or at testing facilities.

C.2 Objective

The objective of this test method is to derive the dynamic properties, dynamic factors for vertical and horizontal loads, system and material damping, free vibration, the (dynamic) loads for the kit and boundary conditions for the component testing, where necessary.

C.3 Principles

The principle of this test is that a full-scale joint is subjected to moving loads exerted by a reference lorry (over rolling test) and that the measurements, e.g. carried out by accelerometers, strain gauges and recordings of laser signals enable a proper dynamic analysis.

One test specimen, subjected to two passing test lorries with different speeds, is sufficient.

The results of the test and analyses apply for joints of the same type, but with other dimensions, provided the calculated vertical, horizontal and rotation natural frequencies do not fall below 90% of those of the originally tested and analysed expansion joint.

Dynamic amplifications and upswing shall be directly calculated from strains.

C.4 Scope and range of application

The evaluation of test results based on this annex is applicable for joints loaded by one axle in the traffic direction only (expansion joint width approximately 1 200 mm). For larger joints the test results can be used in conjunction with additional analyses.

The dynamic assessments described in this annex are based on joints positioned perpendicular to the traffic direction and perpendicular to the main axis of the bridge.

Joints not perpendicular to the traffic direction will show a smoother load application effect and therefore can be considered included. Skew joints are considered covered by investigations on perpendicular joints, if their dynamic properties are equal to perpendicular joints.

C.5 Samples and preparation of test specimens for over rolling tests

The test pieces shall be full-scale joints. The type, which is the most susceptible against dynamic influences, shall be tested (e.g. longest cantilever, worst relations of geometries).

The evenness of the joint shall meet the manufacturer’s design specifications. The evenness of the adjacent pavement shall be of medium quality (See EN 1991-2, 4.2.1, Note 3). The alignment shall be smooth, without discontinuities.

One specimen of each type has to be tested.

The preparation of the test specimen is under the responsibility of the manufacturer.

C.6 Testing arrangement and conditions

C.6.1 Location and conditions

The joint is located in a road and installed similarly to real “built-in” situations. The opening positions of the joint shall be at 60 % of movement capacity (middle position +/- 5 mm. The tests are carried out at ambient temperatures (between +5 °C and +35 °C).

C.6.2 Instrumentation

The instrumentation of the expansion joint shall consist of a combination of accelerometers, strain gauges and displacement sensors on e.g. edge profiles, noise reducing elements (see Figure C.1).

For Nosing expansion joint with noise reducing elements

- The minimum required opening has to be defined
- Strain gauges for measuring bending stress below the cantilever
- Strain gauges for measuring shear stress at both sides
- If the noise reducing elements are bolted to the edge profile, instrumentation of the bolt to measure forces

The instrumentation shall allow a clear analysis of vertical bending, horizontal bending, torsion and/or tilting. The sampling frequency of the instrumentation shall allow a proper analysis of the dynamic behaviour. The accuracy of measured variable shall be at least 5% of the maximum measured value.

The vehicle (see C.7.2) does not need to be instrumented.

A minimum sampling frequency of 10 to 15 times the highest relevant natural frequency (e.g. 1 500 Hz) is recommended for the data acquisition. In addition a minimum sampling frequency shall correspond to 10 times the inverse of the loading time (equal to the sum of length of the wheel print and length of a single contact surface, divided by the vehicle speed).

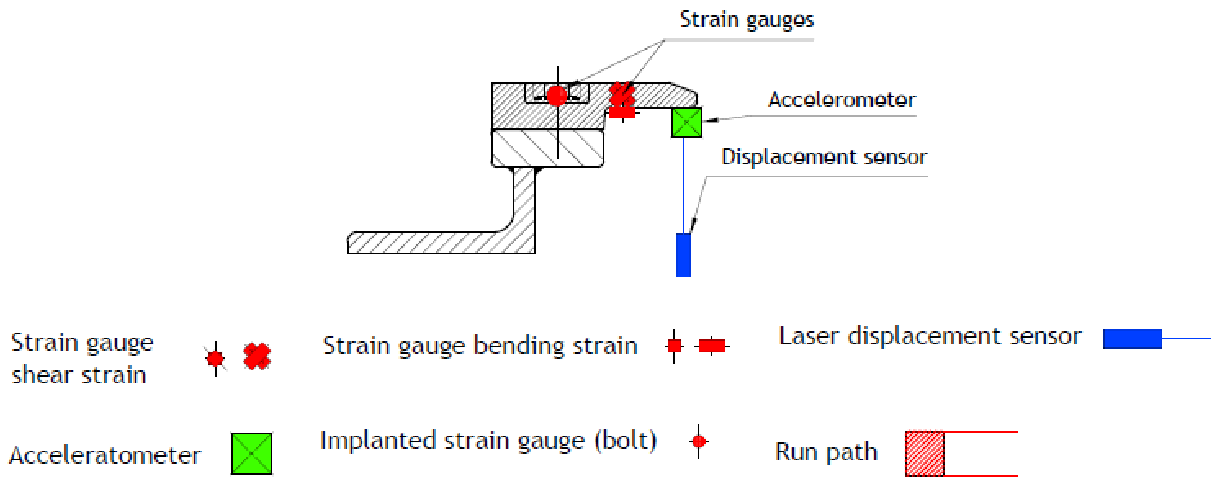


Figure C.1: Typical arrangement of measuring devices

C.6.3 Joint extremities (cantilevers) and other discontinuities

The joint extremities with cantilevering parts larger than 0,3 times the intermediate spans (free cantilevering parts etc.) and other discontinuities shall be assessed with additional accelerometers. The results (Frequencies, natural vectors, accelerations) shall be used for calibration of calculation models used for the assessments according to Clauses 2.2.1 and 2.2.2.

C.6.4 Positioning of measuring devices

The position (see Figure C.2) and the type of measuring devices shall be reported in a plan, which also shows the over rolling positions of the wheels. The plan shall also indicate the channel numbers etc. in order to allow full traceability of the records during interpretation and evaluation.

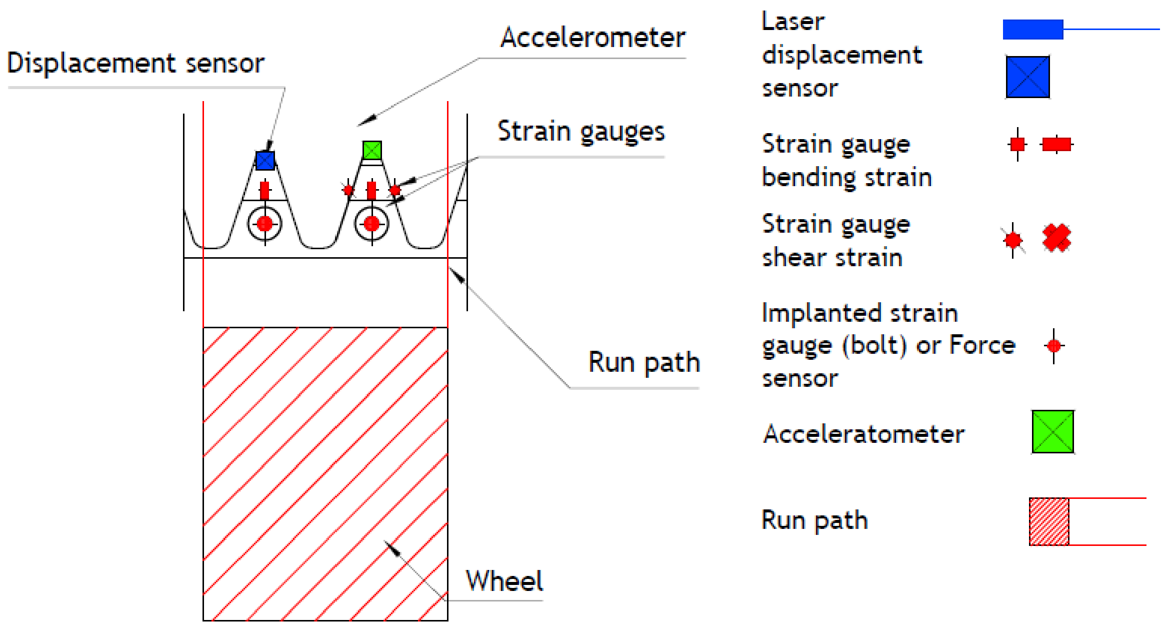


Figure C.2: Transverse position for over rolling

C.7 Load arrangements and execution of over rolling tests

C.7.1 Excitation

Prior to the over rolling test, the natural frequencies and natural vectors of the joint shall be determined.

C.7.2 Over-rolling test

Prior to the over rolling tests, a static measurement of the axle (wheel) loads shall be carried out. The geometry of the wheel prints shall be recorded. This can be achieved with a special measuring device, but also with a contour, drawn on a piece of paper. The static measurement shall be carried out with the same transverse slope as the expansion joint. The tyre inflation shall be recorded.

Subsequently the over-rolling tests are carried out:

A reference lorry travels over the expansion joint with the following speeds:

Table C.7.2: Lorry speeds and positions

Sequence	Speed (km/h)
1	≤ 5
2	50*
3	70*
4	90*

* Determination of test speed by axle spacing and natural frequency

40 km/h < $v=(a_i * f_1 *3,6) / n_{v2}$ <= 60 km/h
60 km/h < $v=(a_i * f_1 *3,6) / n_{v3}$ <= 80 km/h
80 km/h < $v=(a_i * f_1 *3,6) / n_{v4}$ <= 100 km/h
$v = l_{wheel\ print} x f_1$ <= 120 km/h

Where a_i [m] minimum axle spacing of the test lorry
f_1 [Hz] first natural frequency (in vertical and/or horizontal direction)
n_{v2}, n_{v3}, n_{v4} integer
$l_{wheel\ print}$ length of the wheel print
v Lorry speed [km/h]

Sequence 1 simulates a static load transfer through the joint. Sequences 2 – 4 generate dynamic load transfer through the joint.

For each speed and each transverse position the number of over-rolling with the vehicle is at least 3.

The transverse position of the wheel shall be the same as a measuring device.

The vehicle speeds may be achieved by cruise control or manually and shall be recorded.

The (transverse) position of the over rolling wheels shall be reported.

The centre-to-centre distances and the width of the edge profiles shall be reported (gap width).

The as-built drawings of the joint (and its components) are part of the documentation of the test set up.

The following lorry types are recommended:

- Two axle lorry with axle loads as EN 1991-2 FLM4 Type 1: Front axle 70 kN and rear axle 130 kN.
- Five axle lorry with axle loads as EN 1991-2 FLM4 Type 3: Tractor: Front axle 70 kN, Rear axle 150 kN, Trailer tridem 3 x 90 kN.

C.8 Measurements and analyses

The following aspects shall be measured for further interpretation.

C.8.1 Lorry

1. Wheel print geometry (static) (5% accuracy),
2. Tyre pressures (5% accuracy),
3. Travelling speed of the lorry above the joint (5% accuracy),
4. Travelling position in transverse direction (10% accuracy).

C.8.2 Expansion joint

The following shall be measured:

1. Width of the edge profiles/noise reducing elements,
2. Gap width (5% accuracy),
3. Strains (with gauge) (5% accuracy),
4. Accelerations (5% accuracy),
5. Distance (with laser) (5% accuracy).

Interference effects and phase shifts between vertical, horizontal and rotation movements shall be filtered, prior to further analysis.

C.8.3 Over-rolling tests

C.8.3.1 Effects in the vertical plane

C.8.3.1.1 Initial dynamic impact factor

The vertical dynamic impact factor $\Delta\varphi_{fat}$ shall be derived from the vertical section moments. The section moments shall be derived from the section moments at the strain gauge locations, taking into account the transversely distributed load introduced by the wheel print and offsets, if relevant. The moments shall be summed for the determination of the dynamic impact factors. The vertical dynamic impact factor $\Delta\varphi_{fat}$ [-] for the considered velocity is the vertical moment interval (sum of support and midspan moments) for sequence “i” M_{Svi} [kNm], divided by the vertical moment interval for sequence 1 (v = 0) M_{Sv0} [kNm].

Analysis:

- Vertical support moment: M_{sv} [kNm],
- Vertical moment interval static: M_{Sv0} [kNm],
- Vertical moment interval at sequence “i” with ($v \neq 0$): M_{Svi} [kNm],
- Dynamic impact factor: $\Delta\varphi_{fat} = M_{Svi}/M_{Sv0} \geq 1.0$. The dynamic impact factor shall be calculated with the 95%-fractile of the test results.

C.8.3.1.2 Upswing

Derive in the same way the vertical moment interval (M_{Svu} [kNm] = M_{svu} [kNm] + M_{mvu} [kNm]) after unloading.

The vertical Upswing ratio U_v [-] = M_{Svu}/M_{Sv}
The vertical upswing ratio shall be calculated with the 95%-fractile of the test results.

C.8.3.1.3 Combined dynamic vertical effect

The dynamic load (moment etc.) design interval ($E_{d,dyn}$) to be used for fatigue assessments shall be based on:

$$E_{dv,dyn} = E_{dv0} \times \Delta\varphi_{fat} \times (1 + U_v) \text{ [kN]}$$

C.8.3.2 Effects in the horizontal plane

The section moments shall be derived from the section moments at the strain gauge locations, taking into account the transversely distributed load introduced by the wheel print. The moments shall be summed for the determination of the transfer factor. The transfer factor “tr” for the considered velocity is the measured horizontal moment interval for sequence “i” M_{Sh}, divided by the vertical M_{Sv0}.

Analysis:

- Vertical support moment for a static load (v=0km/h): M_{sv0} [kNm],
- Vertical moment interval for a static load (v=0km/h): $M_{Sv0} = M_{sv0} + M_{mv0}$ [kNm],
- Horizontal moment interval for a moving load (v_i > 0km/h): $M_{Shi} = M_{shi} + M_{mhi}$ [kNm],
- Transfer factor V/H incl. $\Delta\varphi_{fat}$: $tr = M_{Shi}/M_{Sv0} \geq 1.0$ [-]. The transfer factor shall be calculated with the 95%-fractile of the test results.

C.8.3.3 Response ratio

Derive in the same way the vertical moment interval ($M_{Svu} = M_{svu} + M_{mvu}$) after unloading.

The horizontal response ratio $U_h = M_{Shu}/M_{Sh}$ [-].

Without further analyses U_h shall be taken as 1,0.

C.8.3.4 Combined dynamic vertical effect

The dynamic load (moment etc.) design interval ($E_{dh,dyn}$) to be used for fatigue assessments shall be based on:

$$E_{dh,dyn} = E_{dh0} \times \Delta\varphi_{fat} \times (1 + U_h) \text{ [kN]}$$

C.9 Calculations

Parallel to the over-rolling test a calculation shall be carried out of the full-scale test expansion joint with a 3-D model.

C.9.1 General

The overall dimensions of the model shall be such that all relevant frequencies and natural vectors are found; therefore the model shall include the relevant features e.g. offsets, inflexion points (bends), cantilevering parts. The model shall enable the calculation of the relevant section forces and bending moment at all cross sections with locations susceptible to fatigue; e.g. butt joint locations.

C.9.2 Calculation results

The natural frequencies and natural vectors shall be calculated. The results shall be compared with the measured natural frequencies and natural vectors that can be derived from the measurements.

For the assessment of the model the measured natural frequencies and mode shapes shall be compared with calculated ones. The strains and deflections due to walking speed over-rolling (according to sequence 1 in Table C.7.2) shall be compared with the simulated ones.

Note: The full-scale test results only allow the derivation of the natural frequencies, whereas the model allows the derivation of natural frequencies and 2nd harmonics. Further small deviations in geometry can give rise to differences between the measurements and the model calculations.

If the model results do not deviate more than 10 %, no further action has to be taken. If the results deviate more than 10 %, additional analyses are needed for a better adjustment, or modifications of the model.

Note: No response calculations need to be carried out if: For upswing effects less than 2% of the quasi static load it can be considered no upswing, for dynamic amplification effects responses not larger than 1.05 the quasi static response can be considered no additional amplification.

C.9.3 Combination of effects

Without further analyses the dynamic stress intervals from vertical loads shall be combined with the dynamic stress intervals from horizontal loads.

For stresses at a specific location from both load effects into the same direction applies:

$$\Delta\sigma_{comb} = \Delta\sigma_v + \Delta\sigma_h \text{ [N/mm}^2\text{]}$$

If needed, the combined stress interval may include the phase shift between vertical and horizontal vibrations, based on additional analyses.

C.10 Test report

The test report shall comprise at least:

- Description of the joint, including the adjacent pavement over 30 m before and after the joint, slopes in traffic direction and perpendicular to the traffic direction;
- Drawing of the joint (dimensions, dimensions of components, material specifications etc.);

- Test lorry (configuration and static wheel loads, wheel print dimensions, inflation pressure of tyres, wheel and axle distances, position relative to the joint in transverse direction during over-rolling, over-rolling speed);
- Measuring devices (types, accuracy) and their locations (detailed sketches, related to the joint dimensions);
- Sampling frequency of measuring devices;
- Natural frequencies (vertical, horizontal, torsional);
- Vertical dynamic amplification factor $\Delta\varphi_{fat}$ for each crossing and 95% quantile;
- Transfer effects tr for each crossing;
- Upswing effect U_v, and horizontal response effect U_H for each crossing and 95% quantile;
- Date of test execution (environmental aspects: air temperature etc.).

C.11 Keys

v	[km/h]	lorry speed
a_i	[m]	minimum axle spacing of the test lorry
$l_{wheel\ print}$	[m]	length of the wheel print
f_1	[Hz]	first natural frequency in vertical and/or horizontal direction
d	[-]	damping ratio
n_{vi}	[-]	integer
$\Delta\varphi_{fat}$	[-]	vertical dynamic impact factor
M_{sv0}	[kNm]	Static vertical support moment (v = 0km/h)
M_{mv0}	[kNm]	Static vertical midspan moment (v = 0km/h)
M_{Sv0}	[kNm]	Static vertical moment interval (v = 0km/h)
M_{Svi}	[kNm]	Vertical moment interval at sequence i (v_i > 0km/h)
M_{svu}	[kNm]	vertical support moment after unloading (v_i > 0km/h)
M_{mvu}	[kNm]	vertical midspan moment after unloading (v_i > 0km/h)
M_{Svu}	[kNm]	vertical moment interval after unloading (v_i > 0km/h)
M_{Shi}	[kNm]	Horizontal moment interval (v_i > 0km/h)
M_{shi}	[kNm]	Horizontal support moment (v_i > 0km/h)
M_{mhi}	[kNm]	Horizontal midspan moment (v_i > 0km/h)
U_v	[-]	vertical upswing ratio
U_h	[-]	horizontal response ratio
$E_{d,dyn}$	[kN, kNm or N/mm²]	vertical dynamic load (moment etc.) design interval
E_{dv0}	[kN, kNm or N/mm²]	vertical static load (moment etc.) design interval (v = 0km/h)
$E_{dh,dyn}$	[kN, kNm or N/mm²]	horizontal dynamic load (moment etc.) design interval
E_{dh0}	[kN, kNm or N/mm²]	horizontal static load (moment etc.) design interval (v = 0km/h)
tr	[-]	transfer factor
$\Delta\sigma_{comb}$	[N/mm²]	combined stress interval
$\Delta\sigma_v$	[N/mm²]	vertical stress interval
$\Delta\sigma_h$	[N/mm²]	horizontal stress interval
A_n	e.g. [µm/m]	response Amplitude "n"

ANNEX D – EXPANSION JOINTS FOR ROAD BRIDGES – TRAFFIC LOADS AND ASSESSMENT METHODS (GENERAL)

Contents

D.1 SCOPE

This annex gives for expansion joints for road bridges:

- The detailing for the determination of the traffic loads and combinations on expansion joints that for (quasi-) static assessment at Ultimate Limit State and, where requested at Serviceability Limit State, and fatigue loads and relevant conditions for assessment of seismic behaviour. It shall be used in combination with pre-stressing, imposed deformations, dead loads and seismic loads, where relevant,
- The assessment method for movement capacity,
- The assessment method for the watertightness,
- The assessment method for the drainage capacity,
- The assessment method for content, emission and/or release of dangerous substances

This annex is also implementing the relevant aspects in ETAG 032, Part 1, Annex G, K and L.

D.2 TRAFFIC LOADS AND COMBINATIONS

D.2.1 General

The wheel load is uniformly distributed on the effective contact areas between the wheel and the surface sub-components, including the kerb units.

The load distribution shall consider the detailing of the contact area according to the zones given below, whereas Figure D.2 does not show necessarily the most adverse position of the wheel print.

Zone 1: Area of the wheel print on the surface of the adjacent pavement,

Zone 2: Area of the wheel print on the surface of the transition strip,

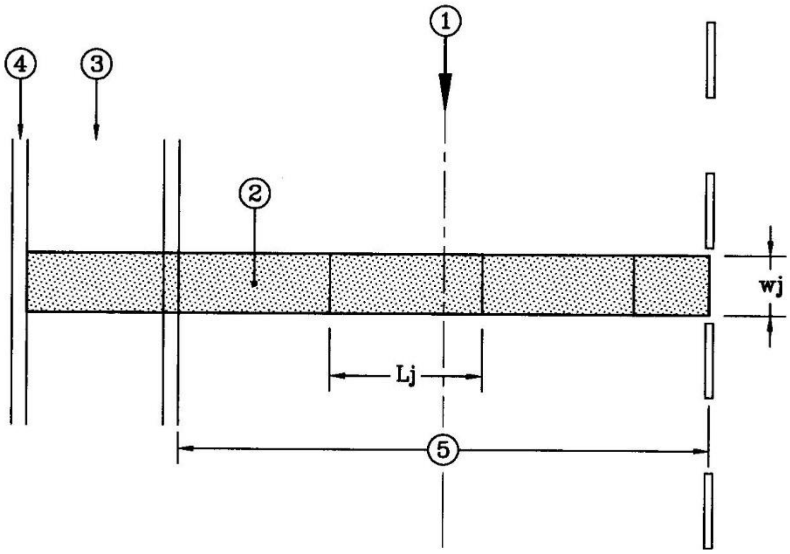
Zone 3: Area where the tyre is fully in contact with the expansion joint sub-component A’ according to Figure D.2,

Zone 4: Area where the tyre is fully in contact with the expansion joint sub-component A’’ according to Figure D.2,

Zones 5’ and 5’’: Areas where the tyre is not supported by the expansion joint (areas of gaps and voids).

This principle applies for vertical forces (contact pressures) and horizontal forces.

The static resistance of the joint is assessed at the most adverse opening position. For each section or part to be assessed the most adverse position of the loads shall be identified by means of influence lines/surfaces in conjunction with the zoning principles.



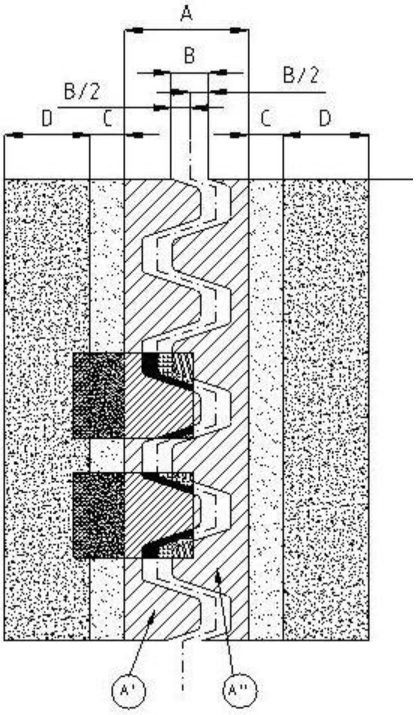
Key: ① Traffic direction ② Expansion joint ③ Footpath ④ Pedestrian parapet ⑤ Lane

L_j: Influence length,

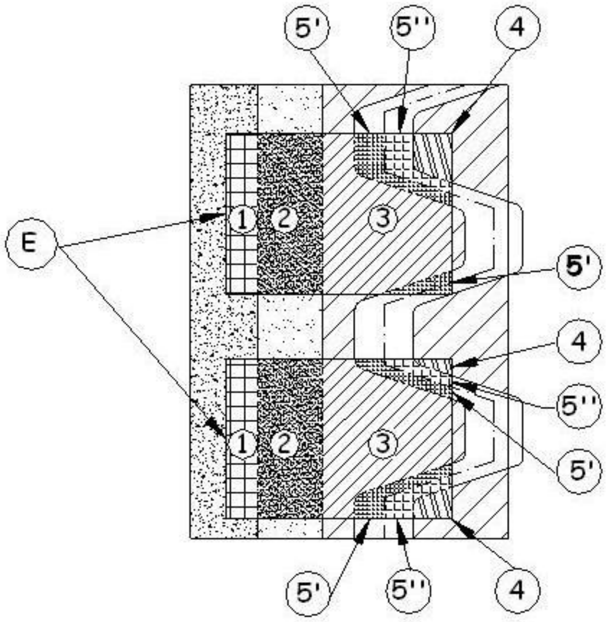
w_j: width of the expansion joint in the traffic direction at the maximum opening. This width includes the joint itself and the adjacent parts which participate in the load transfer.

Figure D.1: Definition of Lj and wj.

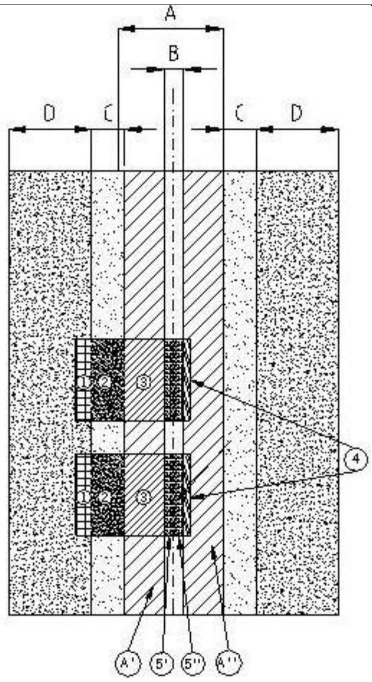
Due attention shall be paid to the skew angle of the expansion joint, where relevant.



General view of wheel print on an expansion joint



Detail on the different areas of wheel print on the expansion joint



General view for expansion joint with straight edges

Key for Figure D.2:

A	Expansion joint,
A’ and A’’	Expansion joint contact surfaces,
B	Gap/voids,
C	Transition strip,
D	Adjacent pavement,
E	Wheel print.

1, 2, 3, 4, 5, 5‘, 5“: Contact zones of the tyre with the different parts of the expansion joint (explanation given in Clause D.2.1)

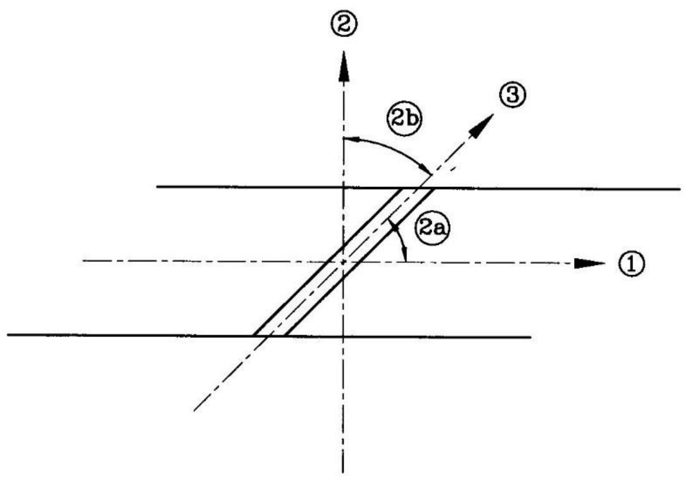
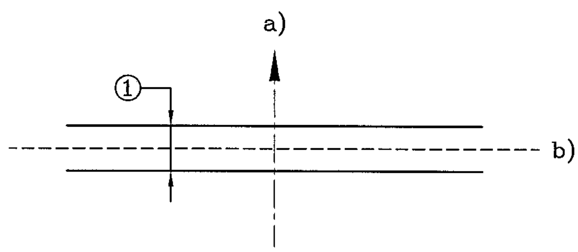
Figure D.2: Principles of wheel load distribution

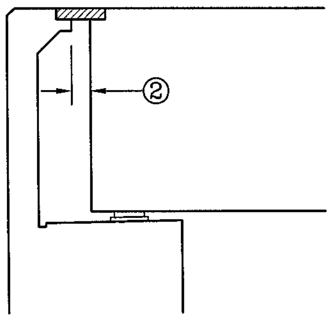
The loads on the areas of zones 5’ and 5’’ shall be added on the nearest supporting area of zones 3 and 4 respectively, whereas the load of zone 5’ goes to zone 3 and the load of zone 5’’ goes to zone 4, unless more detailed in an EAD.

D.2.2 Terms and definitions in this annex

Table D.1 includes specific definitions, terms and abbreviations used in this annex.

Table D.1: Terms and abbreviations used in this annex

Term/Abbreviation	Definition/Explanation	Reference to standards
Definitions		
Skew angle	Considering the existence of two interpretations of the skew of the bridge in Member States, it has two definitions: a) the skew angle is the angle between the road axis and the longitudinal axis of the joint, b) the skew angle is the angle between the axis perpendicular to the road and the longitudinal axis of the joint. The manufacturer will indicate the definition chosen.  1: Road axis in traffic direction; 2: Perpendicular to the road axis; 3: Longitudinal expansion joint axis; 2a and 2b: Skew angle	
Gap 1. Expansion joint gap (Surface gap)	 1. Opening (generally defined by one dimension) with a great length and a relatively small width in the road surface between sub-components of the expansion joint (perpendicular distance between two straight edges or planes): a) Traffic direction b) Longitudinal axis of the expansion joint.  **Note**: In principle, the term gap is not restricted to straight border lines.	

2. Bridge deck gap (Structure gap)	2. Opening between two adjacent parts of the main structure, which is bridged by the expansion joint (distance between two structural elements) 	
Movement	The variation of the distance between the parts of the structures supporting the expansion joint.	
Movement capacity	The range of the relative displacement between the extreme positions (e.g. maximum and minimum opening) of an expansion joint.	
Horizontal displacement	Movement in a horizontal plane imposed on the product tested along an axis perpendicular to the principal axis of the joint.	
Vertical displacement	Movement imposed on the product tested along a vertical axis. It corresponds in particular to the vertical component of rotations of the deck relative to the abutment.	
Transverse displacement	Movement imposed on the product tested along the axis of the joint (occurs on skew bridges, effect of the centrifugal force on the curved bridges, ...).	
Upstand	The vertical or inclined part of the joint which ensures continuity of the joint between road surface level and footway level.	
Terms and abbreviations		
A_{Ed}	Design seismic action	EN 1990, 1.6
C_{FAT}	Combination for fatigue limit state	-
C_{SLS}	Combination for serviceability limit state	-
$C_{SLS\text{-}FREQUENT}$	Frequent combination	-
C_{ULS}	Combination of persistent and transient design situations for ULS	-
$C_{ULS\text{-}ACC}$	Combination for accidental design situation	-
$C_{ULS\text{-}SEISMIC}$	Combination for seismic design situation	-
FLM1	Fatigue load model 1	EN 1991-2, 4.6.1 and 4.6.2
$FLM1_{EJ}$	Fatigue load model 1 for expansion joints	-
$FLM2_{EJ}$	Fatigue load model 2 for expansion joints	-
FLM4	Fatigue load model 4	EN 1991-2, 4.6.1 and 4.6.5
F_{ik}	Characteristic internal force caused by prestress and imposed deformations	-

G	Self weight (permanent action)	EN 1990, 1.6
LM1	Static load model 1	EN 1991-2, 4.3.1 and 4.3.2
L_j	Structural (effective) length of the joint (influence length)	-
N_{obs}	Number of heavy vehicles per year and lane	EN 1991-2, Table 4.5
$P_{D\text{-}wheel}$	Design vertical wheel load	-
S	Wheel print area	-
SLS	Serviceability limit state	EN 1990, 6.5
S_V	Area of gaps and voids	-
Q_V	Summarized adjusted vertical loads for the determination of the summarized centrifugal load	-
Q_{fwk}	Concentrated vertical load simulating pedestrian loads	EN 1991-2, 1.5.2 and 5.1
Q_{ik}	Vertical load of one axle at lane "i"	EN 1991-2, 4.3.1 and 4.3.2
Q_{lk}	Braking load of one axle	EN 1991-2, 1.5.2 and 4.4.1
Q_{tk}	Centrifugal force	EN 1991-2, 1.5.2 and 4.4.2
$Q_{1k,\ fat}$	Vertical axle load of $FLM1_{EJ}$	-
$Q_{1lk,\ fat}$	Horizontal axle load of $FLM1_{EJ}$	-
Q_{2k}	Vertical characteristic traffic load to be used for the assessment of the accidental load on footway (see clause 2.3.1.4)	EN 1991-2, 4.7.3.1
TSi	Tandem system vertical load on lane "i"	EN 1991-2, 1.5.2 and 4.3.2
ULS	Ultimate limit state	EN 1990, 6.4
w_j	Effective width of the expansion joint at maximum opening position	-
b_k	Characteristic value of the deceleration effect	-
d_{Ek}	Maximum opening of the joint declared by the manufacturer	-
d_E	Design seismic displacement of the joint	-

d_G	Opening position of the joint due to displacement caused by permanent and quasi-permanent long term actions on the main structures	-
d_{Tk}	Opening position of the joint due to displacement caused by movements caused by thermal actions on the bridge	-
Greek upper case letters		
$\Delta\varphi_{fat}$	Additional dynamic factor for vertical axle loads for fatigue	EN 1991-2, 1.5.2 and 4.6.1
$\Delta\varphi_{fat,h}$	Additional dynamic factor for horizontal axle loads for fatigue	-
Greek lower case letters		
α_{Qi}, α_{qi}	Adjustment factors of some lane load models on lanes i (i = 1, 2, …)	EN 1991-2, 4.3.2
α_{Q2}	Adjustment factors for accidental load model	EN 1991-2, 4.3.2 and 4.7.3.1
γ_{dE}	Partial factor for opening position of the joint	-
γ_{F1}	Partial load factor in case the consequences of failure are local and/ or minor	-
γ_{F2}	Partial load factor in case the consequences of failure are global and/ or major	-
γ_G	Partial load factor for permanent actions	EN 1990, 1.6
γ_{Qi}	Partial load factor for variable actions (axle loads: TSi)	EN 1990, 1.6
γ_q	Partial load factor for variable actions (distributed loads: UDL)	EN 1990, 1.6
$\sigma_{Contact}$	Contact pressure between wheel and expansion joint surface	-
ψ_{0T}	Combination factor for traffic loads	-
ψ_{0d}	Combination factor for opening position of joint	-
ψ_{0lk}	Combination factor for traffic loads caused by braking lorries	-
ψ_{0tk}	Combination factor for traffic loads caused by centrifugal effects on lorries	-
ψ_{1k}	Combination factor for frequent value of a variable action	EN 1990, 1.6
ψ_{2k}	Combination factor for quasi-permanent value of a variable action	EN 1990, 1.6
ψ_{2d}	Combination factor for quasi-permanent value of the opening position of the joint	-
ψ_3	Combination factor for the quasi-permanent value of thermal actions	-

D.2.3 Static load models

D.2.3.1 Vertical load model

The vertical loads are derived from EN 1991-2, 4.3, Load Model 1, with α_{Qi} (see Clause D.2.3.2).

Deviating from EN 1991-2 modified wheel prints are given because expansion joints are surface elements which require a more accurate modelling of the axle load/road surface interaction.

D.2.3.1.1 Test arrangement

The axle load on one axle of the tandem system TSi is applied on four wheel prints of two dual tyres, each wheel print with l = 0,30 m, b = 0,25 m with a gap between two wheel prints of 0,10 m. The inner distance between the wheels prints is 1,30 m. The geometry is shown in Figure D.3.

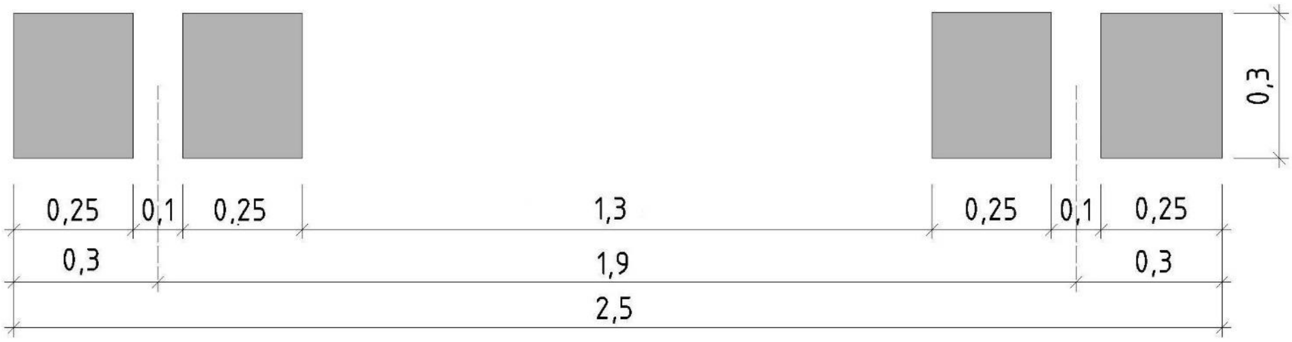
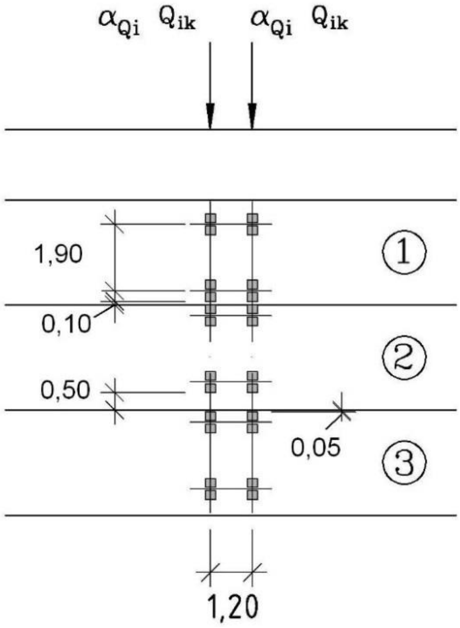


Figure D.3: Wheel print (dimensions are in m)

The tandem systems shall be situated in the most adverse positions on the joint (see Figure D.4).



The numbers 1, 2 and 3 correspond to the lane numbers

Figure D.4: Tandem system arrangement

Note: If it is demonstrated that the loads in lane 3 are not influencing the design of the expansion joint, they can be omitted.

Table D.2 gives the values Q_{ik} of the loads shown in Figure D.4 to be taken into account in conjunction with the geometry of the expansion joint and the structural elements influenced by the traffic load models.

Table D.2: Wheel and axle loads (dimensions are given in m)
Key: ⟶ Traffic direction

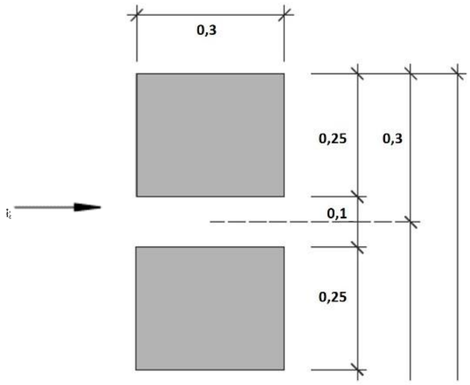
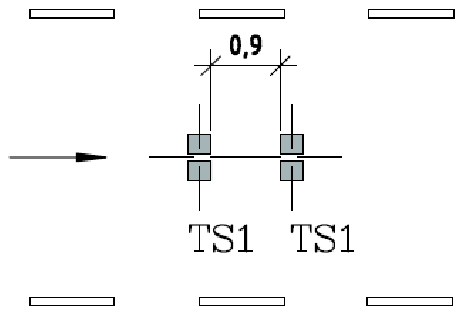
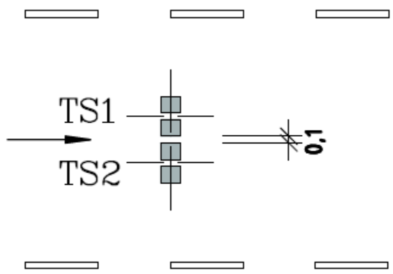
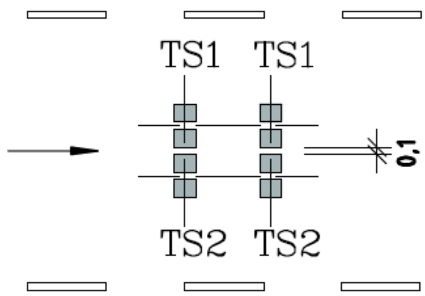
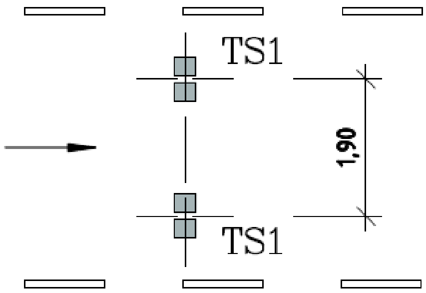
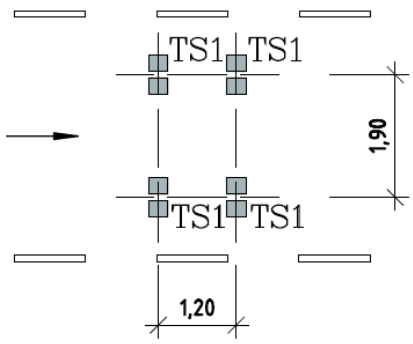
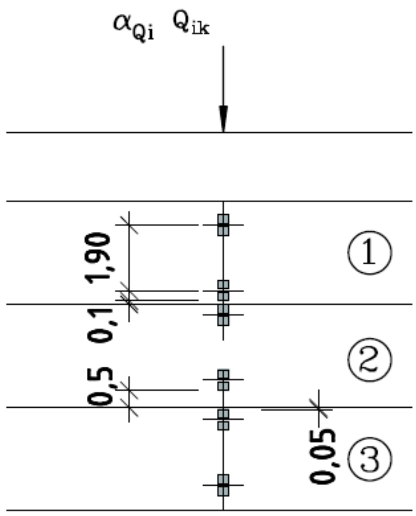
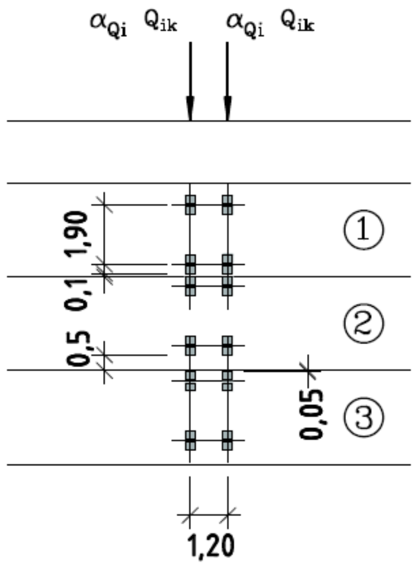
L_j	Wheel and axle loads	
	$w_j \leq 1{,}20$ m	$w_j > 1{,}20$ m
0,6 m *)	$Q_{ik}/2 = 150$ kN (TS1)  Figure A	$Q_{ik}/2 = 150$ kN (TS1)  Figure B
0,6 m – 1,60 m	$Q_{1k}/2 = 150$ kN (TS1) $Q_{2k}/2 = 100$ kN (TS2)  Figure C	$Q_{1k}/2 = 150$ kN (TS1) $Q_{2k}/2 = 100$ kN (TS2)  Figure D

Table D.2 is continued on Page 55

*) In case of L_j is less than 0,6 m, the load shall be reduced accordingly.

Continuation of Table D.2

L_j	Wheel and axle loads	
	$w_j \leq 1{,}20$ m	$w_j > 1{,}20$ m
1,60 m - 2,50 m	Axle load Q_{1k} = 300 kN (TS1)  Figure E	Axle load Q_{1k} = 300 kN (TS1)  Figure F
> 2,50 m	For axle loads see Table D.3  Figure G	For axle loads see Table D.3  Figure H

Key notes for indications given in Table D.2:

(1) The selected position(s) of the axle loads shall be such that they produce the most adverse load effect on the underlying structure between the kerbs. This may result in several load cases with different positions

(2) The minimum distance between two adjacent wheels shall be taken as 0,10 m perpendicular to the traffic direction.

(3) The wheel print shall be taken as shown in Figure D.3.

(4) The dispersal effect of the pavement on the expansion joints, if any, shall be disregarded.

(5) The dynamic amplification is included in the loads, except the effects of resonance.

(6) The loads given in this clause include the effects of the longitudinal and transverse slopes of the road surface.

(7) The load models given in this clause include the unequal load distribution on the axles due to centrifugal forces.

D.2.3.1.2 Load Model 1

Only tandem systems TS as detailed in Table D.3 apply, not the uniformly distributed loads (UDL) as they are not relevant for the expansion joints.

Table D.3: Basic values

Location	**Tandem system**	**Axle loads Q_{ik} (kN)**
Lane number 1	TS1	300
Lane number 2	TS2	200
Lane number 3	TS3	100

D.2.3.1.3 Loads on footways

Concentrated load Q_{fwk} = 35 kN on a wheel print 200 mm x 200 mm. With this concentrated load all load effects are covered.

D.2.3.1.4 Accidental load

(Vehicle on footways and cycle tracks on expansion joints)

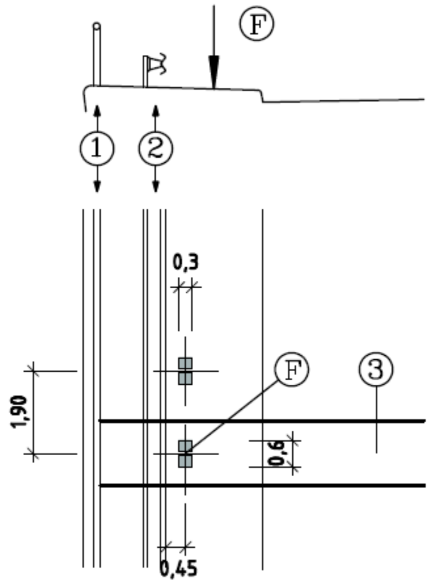
Accidental loads shall be in accordance with EN 1991-2, 4.7.3.1.

(1) Where a safety barrier of an appropriate containment level is provided, consideration of the axle load beyond this point is unnecessary.

(2) Where no safety barrier of an appropriate containment level is provided, one accidental axle load shall be taken into account on the unprotected parts of the joint.

The axle load is: $A_d = \alpha_{Q2} Q_{2k} = 200 kN$ **[D.1]**

With the value of $\alpha_{Q2} = 1,0$



Key: ① Pedestrian parapet ② Safety barrier ③ Expansion joint F = $A_d/2$ = 100 kN

Figure D.5: Accidental loads on footway (dimensions are in m)

D.2.3.2 Horizontal load model

For expansion joints, the horizontal loads are derived from Load Model 1 given in EN 1991-2.

Only tandem systems TS apply, not the uniformly distributed loads UDL as they are not relevant for the expansion joints.

Depending on the width of the expansion joint one axle of a tandem system shall be considered when w_j is smaller than or equal to 1,20 m or two axles when w_j is greater than 1,20 m.

D.2.3.2.1 Braking and acceleration forces

Braking and acceleration forces are assumed to act in the traffic direction and are derived from Load Model 1, TS1 only.

The braking force applied by one axle on a sub-component of the expansion joint shall be calculated with:

$$Q_{lk} = b_k \times \alpha_{Q1} \times Q_{1k} = 120 \text{ kN} \qquad \textbf{[D.2]}$$

The value for α_{Q1} = 1,0 and b_k = 0,4, the characteristic value of the relationship between Q_{lk} and Q_{1k} for the deceleration effect.

Where relevant, the influence of the second axle of TS1 shall be considered.

If there are no other requirements in the EAD, the braking force from a wheel may be distributed on the load carrying sub-components equivalent to the summarized contact stresses, after the subtraction of voids and spaces (see Figure D.2). As a result, the horizontal forces may be the forces caused by one wheel or a part of it.

Braking forces that deviate from the traffic direction do not have to be considered separately as they are covered under D.2.3.2.2 centrifugal forces.

D.2.3.2.2 Centrifugal forces

The centrifugal forces can be derived from Load Model 1.

$$Q_V = \Sigma \alpha_{Qi} \times Q_{ik} \quad \textbf{[D.3]}$$

The centrifugal forces become:

$$Q_{tk} = 0{,}2\ Q_V \quad \textbf{[D.4]}$$

For an axle on lane 1: Q_{tk} = 60 kN
For an axle on lane 2: Q_{tk} = 40 kN
For an axle on lane 3: Q_{tk} = 20 kN

Example: for three axles on lanes 1, 2 and 3: ΣQ_{tk} = 120 kN

The value for α_{Qi} is 1,0 (i = 1 to 3).

The comments in the note given in Table D.2 apply.

Where relevant, the influence of the second axle shall be considered.

D.2.3.2.3 Accidental loads

Collision forces on kerbs of expansion joints.

The expansion joint can be designed for collision forces on kerbs in two different ways:

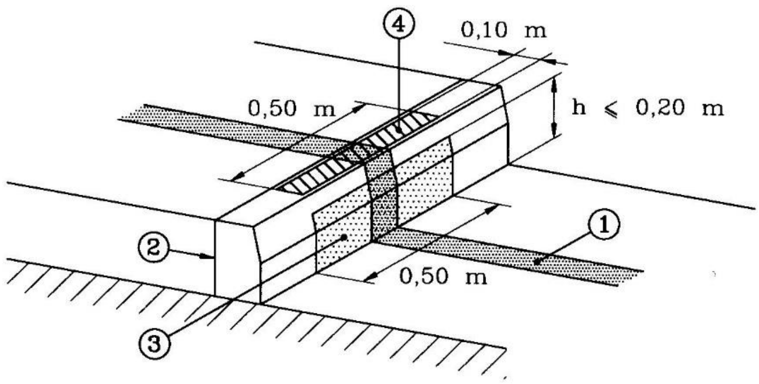
(a) The applied forces shall be in accordance with EN 1991-2, 4.7.3.2 and the structure (expansion joint with kerb unit) is capable of withstanding them without damage (see Clause D.2.3.2.3.1).
(b) The kerb units are repairable and/or replaceable; the collapse does not affect the expansion joint structure (see Clause D.2.3.2.3.2).

D.2.3.2.3.1 Kerb units not repairable and/or not replaceable

The collapse of the kerb unit does affect the expansion joint structure.

The accidental action A_d from vehicle collision with kerbs is taken as a lateral force F_h = 100 kN acting at a vertical surface with a length of 0,5 m and a maximum height of 0,2 m together with a vertical traffic load acting simultaneously with the collision force equal to 0,33 α_{Q1} Q_{1k} on a horizontal surface with a length of 0,5 m and a width of 0,1 m (see Figure D.6) The value for α_{Q1} is 1,0.

A_d = 100 kN (horizontal) "+" 50 kN (vertical)



① Expansion joint ② Kerb ③ Vertical surface for lateral force F_h =100 kN
④ Horizontal surface for vertical force F_v = 50 kN

Figure D.6: Accidental loads on kerbs

D.2.3.2.3.2 Kerb units repairable and/or replaceable

The collapse of the kerb unit does not affect the expansion joint structure.

A horizontal load of 10 kN shall be applied on the kerb. No vertical loads are to be applied. The load distribution is the same as given in Clause D.2.3.2.3.1.

A cover plate is an example of these replaceable and/or repairable kerb units.

A_d = 10 kN (horizontal)

D.2.3.3 Fatigue load models

D.2.3.3.1 General

The Fatigue Load Model 1 ($FLM1_{EJ}$) and the fatigue Load Model 2 ($FLM2_{EJ}$) given hereafter are based respectively on FLM1 and FLM4 of EN 1991-2.

Deviating from EN 1991-2 modified wheel prints are given because expansion joints are surface elements which require a more accurate modelling of the axle load/road surface interaction.

The actions, derived from the fatigue load models, which affect the fatigue behaviour, can be vertical, horizontal or a combination of both. The load models in EN 1991-2 include dynamic load amplification appropriate for pavements of good quality, which is also relevant for expansion joints.

The unevenness and the resonance at the expansion joint may result in an additional dynamic factor $\Delta\varphi_{fat}$ for vertical loads. For horizontal loads, an additional dynamic factor $\Delta\varphi_{fat,h}$ may exist, different from the vertical additional dynamic factor $\Delta\varphi_{fat}$. Upswing after loading (free vibration) shall be considered where relevant.

Since there is no interference between effects of successive axle loads, the load models for expansion joints are defined with respect to axle loads only (not vehicles).

In case of assessment of unlimited fatigue life of the expansion joint $FLM1_{EJ}$ applies.

As an alternative, $FLM2_{EJ}$, which is a set of equivalent axles, may be chosen by the manufacturer.

Table D.4: Axle types, wheel prints and axle geometries

Fatigue load model	**Axle type**	**Wheel print A_w (l x b) [mm]**	**Wheel print axle geometry in transverse direction**
$FLM1_{EJ}$		300 x 250	Wheel print 250 mm, gap 100 mm, wheel print 250 mm, distance 1300 mm, wheel print 250, gap 100 mm, wheel print 250 mm.
$FLM2_{EJ}$	A	300 x 250	Wheel print 250 mm, distance 2 000 mm, wheel print 250 mm.
	B	300 x 250	See $FLM1_{EJ}$.
	C	300 x 333	Wheel print 333 mm, distance 1 834 mm, wheel print 333 mm. As an alternative, for sub-components which are not subjected to the total wheel/axle load, axle C can be replaced by axle A.

For the use of this model, the number of vehicles (N_{obs}) can be selected from EN 1991-2, Table 4.5, and the transverse distribution is given in EN 1991-2, Figure 4.6.

The vertical axle load histogram in Table D.4 is derived from EN 1991-2, Table 4.7, for the Traffic type Medium Distance.

D.2.3.3.2 Fatigue load model 1 ($FLM1_{EJ}$)

The interaction of the vertical and the horizontal force applied by one axle for slopes in the traffic direction not exceeding 4 % shall be calculated with:

$$Q_{1k,fat} = \Delta\varphi_{fat} \times Q_{1k} \times 0{,}7 = 273 \text{ kN} \quad \textbf{[D.5]}$$

$\Delta\varphi_{fat} = 1{,}3$ and $Q_{1k} = 300$ kN

together with:

$$Q_{1lk,fat} = 0{,}2 \times \Delta\varphi_{fat,h} \times Q_{1k} \times 0{,}7 = 42 \text{ kN} \quad \textbf{[D.6]}$$

in traffic direction

$\Delta\varphi_{fat,h} = 1{,}0$

For slopes exceeding 4 % the following applies:

$Q_{1lk,fat} = (7{,}0x + 14{,}0)$ kN

x = slope in %

See also Annex F in this EAD.

D.2.3.3.3 Fatigue load model 2 ($FLM2_{EJ}$)

For the use of this model, the number of vehicles (N_{obs}) can be selected from EN 1991-2, Table 4.5 and the transverse distribution is given in Figure 4.6. For fatigue load model 2 ($FLM2_{EJ}$), the number of vertical axle loads per year is found by multiplying the number of vehicles (N_{obs}) per year from EN 1991-2, Table 4.5, with the axle number rates.

The interaction of vertical and horizontal axle load for slopes in the traffic direction is given in Table D.5.

Table D.5: Vertical and horizontal loads for fatigue

$Q_{1k,fat}$ Vertical axle load kN Including $\Delta\varphi_{fat} = 1{,}3$	**$Q_{1lk,fat}$ Horizontal axle load kN in traffic direction Including $\Delta_{\varphi fat,h} = 1{,}0$**	**Axle number rate**	**Axle type**
100	-	1,10	A
120	-	1,25	C
150	y = 3x + 8	0,20	B
170	y = 4,5x + 6	0,45	B
190	y = 5x + 8	0,45	B

In which x = slope in % with a minimum value of 4.

The loads mentioned in Table D.5, include the additional dynamic factors $\Delta\varphi_{fat} = 1{,}3$ and $\Delta\varphi_{fat,h} = 1{,}0$. These factors may be modified based on over-rolling tests and/or analyses if indicated in the assessment of resistance to fatigue.

See also Annex F in this EAD.

D.2.4 Assessment

D.2.4.1 General

The assessment at the Ultimate Limit State is carried out according to EN 1993-1-1.
The assessment at the serviceability limit state (SLS) is assessing the capability of the expansion joint and its geometry to deal with internal deformations due to the applied loads and with the imposed displacements from the main structure under normal conditions, but also under accidental loads and seismic imposed movements.

In the equations for combinations given below, the sign "+" means: "In combination with".

In expansion joints the horizontal loads cannot occur independent of vertical loads. The factor ψ_0 covers the effect from loads arising from the same source.

D.2.4.2 Combination at the ultimate limit state

The concurrence of traffic loads and opening positions of the joint is combined within different design situations using combination factors ψ_{0T}, ψ_{0d}, ψ_{0lk}, ψ_{0tk}.

The vertical traffic loads and combinations are derived from Load Model 1.

D.2.4.2.1 Traffic loads and design situations (combinations)

This combination of persistent and transient design situations for ULS may lead to various combinations depending on the geometry of the joint sub-components and the influence lines or surfaces associated with it.

$$\mathbf{C_{ULS}} = \gamma_{Gi}\, G_k \text{ "+" } \gamma_F\, F_{ik} \text{ "+" } \psi_{0T}\, \gamma_{Q1}\, [Q_{1k} \text{ "+" } (\psi_{0lk}\, Q_{lk1} \text{ "+" } \psi_{0tk}\, Q_{tk1}) \text{ "+" } Q_{2k} \text{ "+" } (\psi_{0tk}\, Q_{tk2}) \text{"+" } Q_{3k} \text{ "+" } (\psi_{0tk}\, Q_{tk3})] \text{ "+" } \gamma_{dE}\, \psi_{0d}\, d_{Ek} \qquad \textbf{[D.7]}$$

The values of the partial factors γ are given in Table D.5 bis and the values of the combination factors ψ_0 are given in Table D.6.

Table D.5 bis: Partial factors γ

Partial factor	Unfavourable	Favourable	Remark
γ_{Gi}	1,35	1,00	
γ_{F1}	1,20	0,90	In case the consequences of failure are local and/ or minor
γ_{F2}	1,50	0,70	In case the consequences of failure are global and/or major
γ_{Qi}	1,35	Not applicable	
γ_{dE}	1,00	Not applicable	

Table D.6: Combination factors ψ_0

C_{ULS}	Design situation	ψ_{0T}	ψ_{0d}	ψ_{0lk}	ψ_{0tk}
1	Reduced opening position with maximum traffic loads, flowing traffic with centrifugal effects	1,00	0,60	0,00	0,50
2	Maximum opening position with reduced traffic loads, braking traffic with centrifugal effects	0,70	1,00	0,50	0,50

As an envelope approach, covering all design situations, the ψ_0 factors can be taken as follows:

ψ_{0T} and ψ_{0d} = 1,00
ψ_{0lk} and ψ_{0tk},= 0,50

Example for flowing and braking traffic:

ULS 1, Reduced opening position with maximum traffic loads, flowing traffic with centrifugal effects, unfavourable, consequences of failure due to internal forces are local and/or minor.

$C_{ULS\text{-}1}$= 1,35 G_k *vertical* "+" 1,2 F_{ik} "+" 1,35 x 1,00 [300 kN *vertical* "+" (0,00 x 120 kN *horizontal longitudinal* "+" 0,50 x 60 kN *horizontal perpendicular*) "+" 200 kN *vertical* "+" (0,50 x 40 kN *horizontal perpendicular*)"+" 100 kN"+" 0,50 x 20 kN *horizontal perpendicular*)] "+" 0,6 x d_{Edec}

ULS 2, Maximum opening position with reduced traffic loads, braking traffic with centrifugal effects unfavourable, consequences of failure due to internal forces are local and/or minor.

$C_{ULS\text{-}2}$= 1,35 G_k *vertical* "+" 1,2 F_{ik} "+" 1,35 x 0,70 [300 kN *vertical* "+" (0,50 x 120 kN *horizontal longitudinal* "+" 0,50 x 60 kN *horizontal perpendicular*) "+" 200 kN *vertical* "+" (0,50 x 40 kN *horizontal longitudinal*) "+" 100 kN "+" 0,50 x 20 kN *horizontal perpendicular*)] "+" 1,00 x d_{Edec}

With $d_{Edec} = \gamma_{dE}\ d_{Ek}$

See also Annex E in this EAD.

Note: Expansion joints may show internal forces from imposed displacements, rotations and/or prestressing caused by e.g. compression or elongation, and/or relative movements.

A wheel load is 0,5 times the axle load. The position of the axles shall be in accordance with Clause D.2.3.1.1. The load portion transfer shall be in accordance with Clause D.2.1.

Table D.7: Information on quasi static loads

Origin	Value	Direction	Positioning	Load portion in accordance to
Self-weight, G_k	Defined by manufacturer	Vertical		
Effects of reaction forces, F_{ik}	Defined by manufacturer (result of movement test)	-		
Lane 1, Q_{1k}	Axle 300 kN	Vertical	D.2.3.1.1	D.2.1
Lane 2, Q_{2k}	Axle 200 kN	Vertical	D.2.3.1.1	D.2.1
Lane 3, Q_{3k}	Axle 100 kN	Vertical	D.2.3.1.1	D.2.1
Lane 1 Q_{lk1}	Axle 120 kN	Horizontal traffic direction	D.2.3.1.1	D.2.1
Lane 1, Q_{tk1}	Axle 60 kN	Horizontal perpendicular to traffic direction	D.2.3.1.1	D.2.1
Lane 2, Q_{tk2}	Axle 40 kN	Horizontal perpendicular to traffic direction	D.2.3.1.1	D.2.1
Lane 3, Q_{tk3}	Axle 20 kN	Horizontal perpendicular to traffic direction	D.2.3.1.1	D.2.1
Accidental loads on footpath and cycle track, A_{k1}	Wheel 100 kN	Vertical	EN 1991-2, 4.7.3.1 (1) and (2)	D.2.1
Accidental load on kerb, A_{k2}	Wheel 100 kN	Horizontal	EN 1991-2, 4.7.3.2 (1)	D.2.1

D.2.4.2.2 Combinations for accidental situations

This combination of accidental design situations for ULS may lead to various combinations depending on the geometry of the joint sub-components and the influence lines or surfaces associated with it.

On the carriageway no accidental loads are considered. The effect of accidental loads is local (on footpath and kerb) and therefore shall only be combined with the traffic loads on Lane 1.

$\mathbf{C_{ULS\text{-}ACC}}$= G_k "+" F_{ik} "+" ψ_{2k} (Q_{1k} "+" Q_{lk1} "+" Q_{tk1}) "+" A_d"+" ψ_{2d} d_{Ek} **[D.8]**

Example for accidental vehicle load on kerb:
ULS ACC, unfavourable, consequences of failure due to internal forces are local and/ or minor, simulating flowing traffic.
$\mathbf{C_{ULS,A2}}$= G_k *vertical* "+" F_{ik} "+" 0,3 [300 kN *vertical* "+" 120 kN *horizontal longitudinal* "+" 60 kN *horizontal perpendicular*) "+" (100 kN *horizontal perpendicular* "+" 50 kN *vertical*) + 0,6 d_{Ek}

The quasi-permanent value of traffic actions on expansion joints corresponds to a lower bound of moving axles, and therefore is not zero.

For the combination $\mathbf{C_{ULS,A1}}$ simulating an accidental wheel load on the footpath

ψ_{2k} = 0,30
ψ_{2d} = 0,60

For A_d see Clause D.2.3.1.4.

γ_{Q2} = 1,0

For the combination $\mathbf{C_{ULS,A2}}$ simulating an accidental load on the kerb

ψ_{2k} = 0,30
ψ_{2d} = 0,60

A_d: see Clause D.2.3.2.3.1 and Clause D.2.3.2.3.2.

D.2.4.2.3 Combination for seismic design situations

D.2.4.2.3.1 Seismic behaviour

Design requirements under seismic conditions consider the importance of the bridge and of the expansion joint. Different categories A and B are given in order to achieve this objective. They consider different behaviours under and after seismic conditions, giving corresponding values of d_{ek} and A_{ed}. These categories are further subdivided into categories A1, A2 (movement capacity design) and B1, B2, B3, B4 (restricted movement and load capacity design), see Table D.8. No fatigue design check is required.

The requirements are associated with each category and are summarized below.

A1 and A2. The expansion joint is not affected by seismic actions under loading conditions defined in Clause D.2.4.2.3.2.

B1. No damage with reduced load bearing capacity and increased gap width during earthquake. $\mathbf{C_{ULS\text{-}SEISMIC}}$ according to the seismic design combination B1 (see Clause D.2.4.2.3.2 for an example).

B2. Minor damage to secondary sub-components and non load carrying sub-components. Load carrying sub-components are allowed to have a reduced load bearing capacity and increased gap width under the seismic design situation.

Secondary sub-components and non load carrying sub-components (e.g. seal sub-components) are allowed to be damaged. Both of these sub-components shall be replaceable or repairable after the earthquake. For the other design requirements see category B1.

B3. Minor damage to primary sub-components or fusible devices due to a combination of reduced traffic load bearing capacity and increased gap width during earthquake. The resistance of load carrying structural elements shall be checked for the seismic design situation $\mathbf{C}_{\mathbf{ULS\text{-}SEISMIC}}$ (see Clause D.2.4.2.3.2 for an example).

The expansion joint is assumed to be resistant to frequent traffic loads according to EN 1990 after the earthquake and to fulfil all the Ultimate and Serviceability Limit State requirements after small repairs.

The sub-components with minor damage shall be easily replaceable with no need of immediate repair.

B4. Major damage to fusible devices and minor damage on the joint. No remaining load bearing capacity and increased gap width after the earthquake.

The combinations of loads defined in Clause D.2.4.2.3.2 shall be used to assess the resistance of load carrying structural elements during the earthquake.

The detailing of expansion joint parts to be damaged during the design seismic event has to be provided with the predictable mode of failure.

The possibility of permanent repair shall be described.

In the case of emergency traffic after the seismic event, the expansion joint shall comply with category B3 load carrying requirements and the width (in the traffic direction) of possible gaps shall be as a maximum 300 mm.

Note: Occurring level differences may cause the need for temporary measures enabling the emergency vehicles to pass the joint at slow speed. Short-term repairs may be required.

Table D.8: Behaviours under and after seismic conditions

Category	**Requirement**	**During design earthquake**		**After design earthquake**	
		Actions	**Safety in use**	**Load bearing capacity and Serviceability**	**Expected repair work**
A	**Full movement capacity**				
A.1	Movement capacity at SLS condition even during the earthquake	Fundamental combination	As for the SLS condition	As before the earthquake	None
A.2	Movement capacity for the total displacement d_{Ed}	Frequent combination	Maximum gap (1) 160 mm	As before the earthquake	None
B	**Limited movement and load capacity design**				
B1	No damage but reduced load capacity during earthquake	Seismic design	Maximum gap (1) 160 mm	As before the earthquake	None

B2	Minor damage to secondary elements and reduced load capacity during earthquake	Seismic design	Maximum gap (1) 160 mm	Load capacity as before the earthquake	Replacement of secondary elements
B3	Minor damage to structural elements or fusible devices and reduced load capacity during earthquake	Seismic design	Maximum gap (1) 240 mm	Original behaviour after small repairs	Small repairs on structural elements and fusible devices
B4	Damage to fusible devices and no load carrying capacity after the earthquake	Seismic design combination	No gap (1) limitation	Maximum gap 300 mm for Emergency Traffic	Permanent repair required

(1) Gap = Expansion joint gap

If applicable both longitudinal, transversal and vertical seismic displacements and their combination shall be considered.

Limitations for gaps and voids during the seismic event in the running surface are given in Table D.8 or in the EAD.

D.2.4.2.3.2 Seismic design situation

When the design of the expansion joints includes provisions limiting movements of the bridge, thus preventing the joint from being affected by seismic effects, no combination for seismic design situations exists. (Clause D.2.4.2.3.1, category “A1”).

For category “A2”, the seismic design situation for ULS is given by:

$$\mathbf{C_{ULS\text{-}SEISMIC}} = G_k \text{ "+" } F_{ik} \text{ "+" } \psi_{1k} [Q_{1k} \text{ "+" } Q_{lk1} \text{ "+" } Q_{tk1}] \text{ "+" } A_{Ed} \qquad \textbf{[D.9]}$$

ψ_{1k} = 0,4
A_{Ed} = Design seismic action (imposed displacements considering the simultaneity of longitudinal, transversal and vertical seismic displacements, for the derivation of the internal forces)

$$A_{Ed} = d_E \text{ "+" } d_G \text{ "+" } \psi_3 d_{Tk} \qquad \textbf{[D.10]}$$

The displacements shall be combined in the most adverse conditions.

– ψ_3 is given in Table D.9.

The total design seismic displacement shall be increased by the displacement due to second order effects when such effects have a significant contribution.

Example for seismic design situation A2:

ULS seismic, In this combination A_{Ed} represents the conditions (a displacement d_{Ed} "+" d_G "+" 0,5 d_{Tk}) for which the joint is analysed and the internal forces are derived.

$\mathbf{C_{ULS\text{-}seismic}}$= G_k *vertical* "+" F_{ik} "+" 0,4 [300 kN *vertical* "+" 120 kN *horizontal longitudinal* "+" 60 kN *horizontal perpendicular*) "+" (d_E "+" d_G "+" 0,5 d_{Tk})

The seismic design combinations “A1” and “A2” are selected for seismic actions with a high probability of occurrence or with smaller values for A_{Ed}.

For categories “B”, the combination of seismic design situations for ULS may lead to various combinations: depending on the geometry of the joint sub-components.

$$C_{ULS\text{-}SEISMIC} = G_k \text{"+"} F_{ik} \text{"+"} \psi_{2k} [Q_{1k} \text{"+"} Q_{lk1} \text{"+"} Q_{tk1}] \text{"+"} A_{Ed} \quad \textbf{[D.11]}$$

ψ_{2k} = Combination factor for quasi-permanent value of a variable action for combinations B1 – B4 as given in Table D.9.

Table D.9: Seismic design combination factors for categories A2, B1 – B4

Category	Combination factor ψ_3/ψ_2	Remark
A2	0,50	During earthquake
B1	0,30	-
B2	0,10	-
B3	0,10	During earthquake
	0,20	After earthquake
B4	0,00	During earthquake
	0,20	On the joint after earthquake
	0,00	On the fuses after earthquake

Limitations for gaps and voids during the seismic event in the running surface are given in the Table D.8 or in the EAD.

D.2.4.2.4 Combination for fatigue limit state

The fatigue limit state is the situation beyond which the structure has not sufficient bearing capacity due to crack growth after a certain number of load cycles.

The fatigue life shall be evaluated for the most adverse positions of the traffic loads.

The interaction between vertical and horizontal loads shall be considered, where relevant.

Combination for fatigue limit state:

$$C_{FAT} = F_{ik} \text{"+"} [Q_{1k,fat} \text{"+"} Q_{lk1,fat}] \text{"+"} \psi_{0d} d_{Ek} \quad \textbf{[D.12]}$$

ψ_{0d} = 0,6
d_{Ek} = for the relation between d_{Ek} and d_{Edec}, see Clause D.2.4.2.1

The value of factors $\Delta\varphi_{fat}$ and $\Delta\varphi_{fat,h}$ is given in Clause D.2.3.3.2.

$Q_{1k,fat}$ and $Q_{lk1,fat}$ in **[D.12]** are axle loads in relation to the number of vehicles (N_{obs}) for the fatigue load model considered, for $FLM1_{EJ}$ the number of vehicles (N_{obs}) is irrelevant, for $FLM2_{EJ}$, see Clause D.2.3.3.3.

Example for fatigue for assessment of unlimited fatigue life:

C_{FAT}= F_{ik} "+" [210 kN *vertical* "+" $\Delta\varphi_{fat,h}$ 42 kN *horizontal*] "+" 0,60 maximum declared opening position of the joint.

Where relevant, the free vibration and damping effect shall be considered.

D.2.4.3 Combinations at the serviceability limit state

Symbols as for ULS combinations.

D.2.4.3.1 Characteristic combination

The loads shall be combined as defined below

$\mathbf{C_{SLS}}$= G_k "+" F_{ik} "+" ψ_{0T} [Q_{1k} "+" (ψ_{0lk} Q_{lk1} "+" ψ_{0tk} Q_{tk1}) "+" Q_{2k} "+" (ψ_{0tk} Q_{tk2}) "+" Q_{3k} "+" (ψ_{0tk} Q_{tk3})] "+" ψ_{0d} d_{Ek}

[D.13]

d_{Ek} = for the relation between d_{Ek} and d_{Edec}, see Clause D.2.4.2.1

The values of the combination factors ψ_0 are given in Table D.6.

As an envelope approach, covering all design situations, the ψ_0 factors can be taken as follows:

ψ_{0T} = 1,00, ψ_{0d} = 1,00, ψ_{0lk} = 0,50, ψ_{0tk} = 0,50

Example for characteristic combination:

SLS, Reduced opening position with maximum traffic loads, flowing traffic with centrifugal effects

$\mathbf{C_{SLS,CHAR}}$= G_k "+" F_{ik} "+" 1,00 [300 kN *vertical* "+" (0,00 x 120 kN *horizontal longitudinal* "+" 0,50 x 60 kN *horizontal perpendicular*) "+" 200 kN *vertical* "+" (0,50 x 40 kN *horizontal perpendicular*) "+" 100 kN *vertical* "+" (0,50 x 20 kN *horizontal perpendicular*)] "+" 0,6 x d_{Ek}

See also Annex E in this EAD.

D.2.4.3.2 Frequent combination

The relevant design situation is flowing traffic.

Combination is:

$\mathbf{C_{SLS-FREQUENT}}$= G_k "+" F_{ik} "+" ψ_{1T} [Q_{1k} "+" ψ_{0lk} Q_{lk1} "+" Q_{2k} "+" Q_{3k}] "+" $\psi_{1d}d_{Ek}$ **[D.14]**

ψ_1 = Combination factor for variable actions
ψ_{0lk} = 0,50
ψ_{1T} = 0,70
ψ_{1d} = 0,60

Example for frequent combination:

SLS, unfavourable, simulating flowing traffic

$\mathbf{C_{SLS,FREQUENT}}$= G_k "+" F_{ik} "+" 0,7 [300 kN "+" 200 kN "+" 100 kN] "+" 0,6 x d_{Ek}

See also Annex E in this EAD.

D.3 ASSESSMENT OF MOVEMENT CAPACITY

D.3.1 Terms and definitions

See Clause D.2.2.

Table D.10: Relation transactional movement of "2" with respect to "1" (see Figure D.7).

X	Main direction along an axis perpendicular to the principal axis of the joint	Variable by actuator
Y	Transverse	Variable by actuator
Z	Vertical	Variable or constant by mechanical devices filling plates or actuator

Movements in x, y and z may be combined.

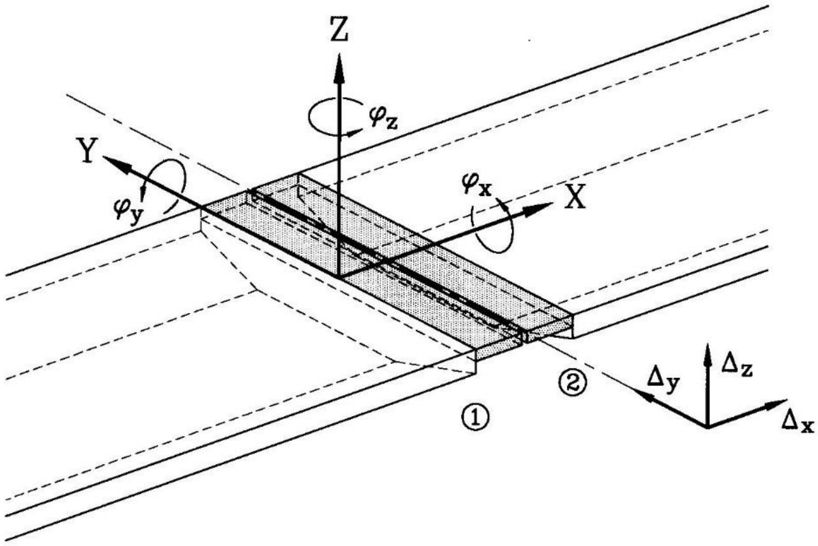


Figure D.7: Combination of movements

D.3.2 Equipment

A sub-component or a section of an expansion joint for road bridges is fixed in a frame with moving parts allowing a horizontal displacement perpendicular and parallel to the bridge deck gap axis.

Vertical displacement can be generated by a device ensuring a continuous displacement or by shim plates under one of the tested joint supports. The principle of the test frame is represented in Figure D.8.

The device shall be equipped to measure the values of the movements and the forces necessary to obtain the displacements.

The testing machine consists of a frame including one or two moving supports which allow the fixing of the joint.

Requirements on testing machine:

- The stiffness of the machine shall be such that the generated forces in the expansion joint tested do not influence the results of the measurement.
- Friction forces in the testing equipment shall not influence the measured results by more than 10 %.
- The movement capacity in each degree of freedom of the testing machine shall be sufficient in order to be able to carry out the test.
- The connections of the test specimen at the testing machine shall be rigid enough to avoid uneven movement in the connections.
- Vertical displacements shall be possible for an offset of 20 mm.

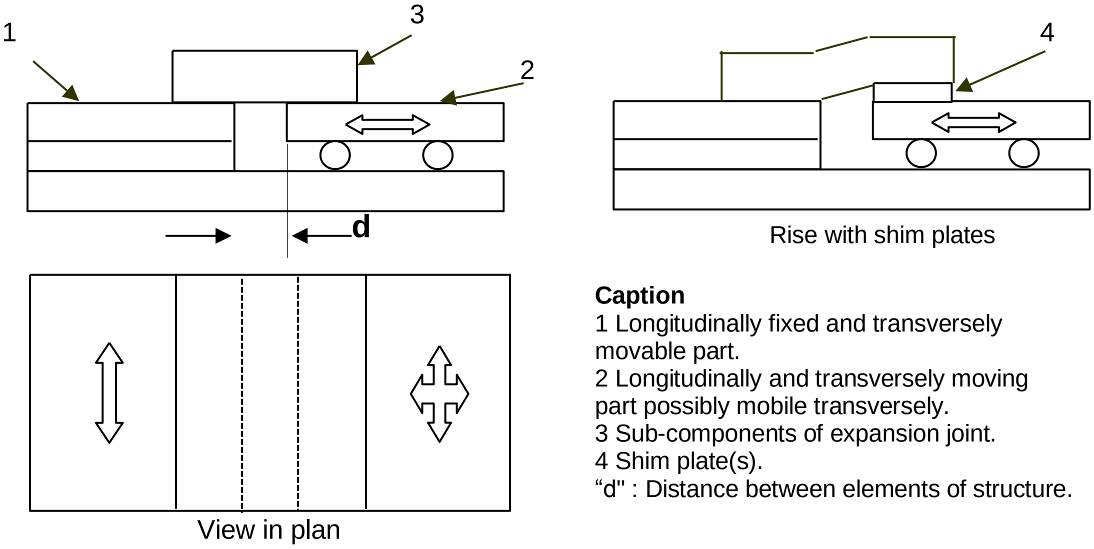


Figure D.8: Example of a test assembly

Displacements are generated by devices whose type and capacity are appropriate to the model of joint tested.

In the test reaction forces and deformations of the sample shall be measured.

The measurement of loads and deformations together with the type of sensors and their location at the test specimen is specified before the beginning of the test.

For materials subject to a load-dependent creep, the creep and relaxation effects in time shall be evaluated and taken into account.

The displacement measurements are carried out using comparators or possibly incremental position sensors allowing the recording of the test data.

The accuracy of the measuring apparatus of the forces shall be 5 % of the maximum reaction force, the resolution of the incremental position sensors shall be ±1/10 mm, in order to obtain a precision of measurements of the order of ±1 mm.

D.3.3 Samples and preparation of the test specimen

This section specifies a method to assess by testing the ability of an expansion joint to accommodate the movements of the structure. These movements are evaluated in three dimensions.

Where the movement capacity of the expansion joint is influenced by the temperature, this influence shall be evaluated and if relevant be taken into account in movement capacity test procedure.

The test is carried out in the laboratory on a sample of expansion joint for road bridges with a representative length of at least 1 metre (exception subject to agreement with TAB).

The preparation of the test specimen is under the responsibility of the manufacturer.

D.3.3.1 Dimensions

The joint sample shall be representative of the assembled expansion joint. Where relevant in the expansion joint, the test piece shall comprise assembly details between adjacent parts in the longitudinal direction of the expansion joint.

The exact length of the sample is fixed by agreement between the manufacturer, the TAB and the test laboratory according to the type of product in order to avoid cuts modifying the operating mode.

The minimum length of the test specimen shall be 1 m unless otherwise specified in the EAD.

Note: It is recommended that the test specimen has a length corresponding to the nominal length of a standard manufactured element.

D.3.3.2 Control of specimens

A detailed description of the test specimen (including specification of the kit and its components and including tolerances) is to be provided and included in the test report.

The minimum number of test specimens is one. For products where larger variations in the mode of operation is expected, it is recommended for products which show a variation in functioning, to use 3 test samples.

D.3.3.3 Installation of the specimens on the test frame

The product to be tested shall be installed in the testing rig under control of the manufacturer and shall comply with the installation procedure

D.3.4 Testing

D.3.4.1 Testing conditions

The test is carried out under the following conditions:

- Test temperature

The ambient temperature during the tests shall be between +5 °C and +35 °C. Where relevant, the individual EAD gives details if the ambient temperature, defined in this clause, is not appropriate for carrying out the test and which procedures for testing are applicable.

- Test speed

The speed of longitudinal and transverse displacements during the test shall not exceed 1 mm/s between the stages of observation. A complete cycle shall not exceed 24 hours.

D.3.4.2 Testing procedure

The test temperature shall be recorded continuously.

The devices of measuring of displacements shall be fixed in order to record the movements correctly.

The test specimen shall be subjected to movements which simulate opening and closing of the joint.

The test comprises 6 cycles (see Figure D.9). For each cycle, the maximum relative displacement of the test specimen as designed by the producer is subdivided into a minimum of 4 steps, each 25 % of the maximum relative displacement. The test may start at any desired position within the maximum relative displacement. After completion of each step, a dwell period is allowed.

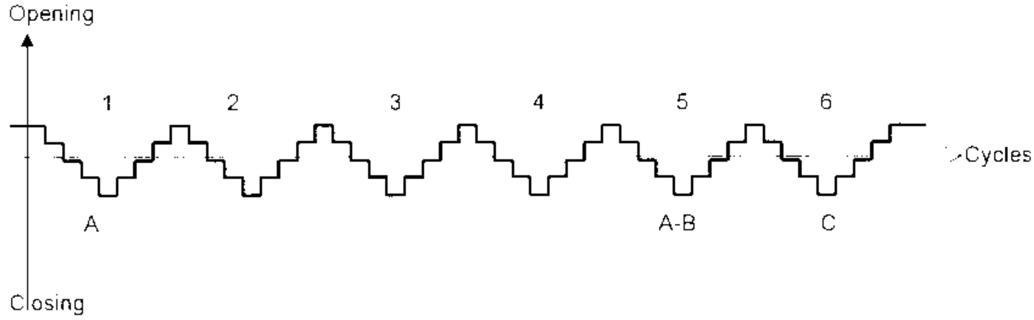
During cycle 1 and cycle 5, the displacements are measured together with the reaction forces.

During the 5th cycle, the transverse movement capacity is assessed in combination with the total range of longitudinal movement and the values of corresponding reaction forces are recorded.

For the joints having a symmetrical operation under transverse solicitation, the checking is necessary in one direction only.

In a 6th cycle the supports are positioned with a vertical offset in order to simulate the unevenness of supports. Only opening and closing movements are applied, no transverse movements. When the joint has a different behaviour for an upward movement compared to a downward movement both directions shall be measured.

The behaviour and the appearance of the joint shall be recorded.



A: Measure of F at opening and closing position
B: Transversal movement with opening/closing movement
C: Vertical movement with opening/closing movement

Figure D.9: Description of cycles during test procedure for movement capacity

D.3.5 Expression of results

Displacements are expressed in mm and the forces in N.

The following results are recorded and expressed using figures and/or graph(s) where appropriate:

- Measurements "d" reached during 1st and 5th cycles (opening, closing) (see Figure D.9);
- Graphs of force/deformation as recorded in the cycles 1, 4, 5, 6;
- Maximum transverse displacement(s) during the 5th cycle;
- Measurements "d" reached during the 6th cycle with unevenness and its corresponding value;
- Forces corresponding to each position previously written;
- Observations of behaviour shall be described and supported with photographs.

D.3.6 Test report

The test report shall mention at least:

- The origin of the expansion joint to be tested (the name of the manufacturer, the name of the manufacturing plant);
- The model identification (type, theoretical movement capacity, N° of batch);
- A reference to this annex
- Description of the test equipment;
- The date of the preparation of specimens, the date of test and the mean test temperature;
- The statement of principal dimensions which allow for unique identification of the product tested;
- A brief description of the test conditions (assembly, description of the specimen, speed of displacements, stages, ...);
- Values of displacements and the forces related obtained during the test;

- Observations on the behaviour corresponding to each stage;
- Test conditions and operational details not envisaged in this document as well as the possible incidents likely to have affected the results.
- A description of any disorder and operating mode possibly appearing on the joint (cracking of rubber, rolling off the rim, abnormal deformations, etc.) is made for each stage of the test procedure.

D.4 ASSESSMENT OF WATERTIGHTNESS

D.4.1 General

This test method is used in order to assess the water tightness of the expansion joint. It is not intended for the assessment of a drainage systems or collection of water by means of additional devices. (Remark: percolation is different to moisture at bottom surface).

The test is carried out to assess that water cannot pass through the expansion joint.

D.4.2 Terms and definitions

See Clause D.2.2.

D.4.3 Principle

The test shall be carried out on one specimen without ageing prior to the execution of the test. The test involved subjecting the specimen of the expansion joint to the action of a defined head of water on the joint. There shall be no moisture under the joint.

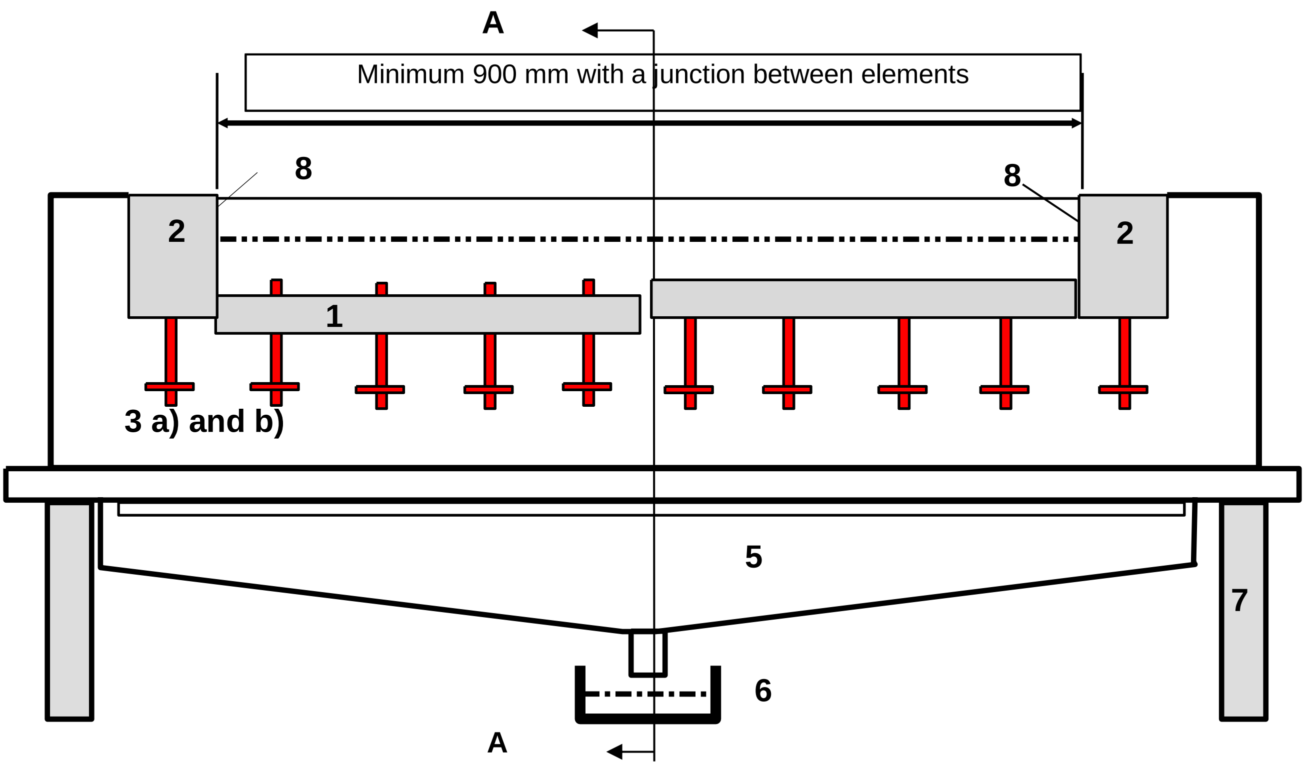


Figure D.10a: Elevation

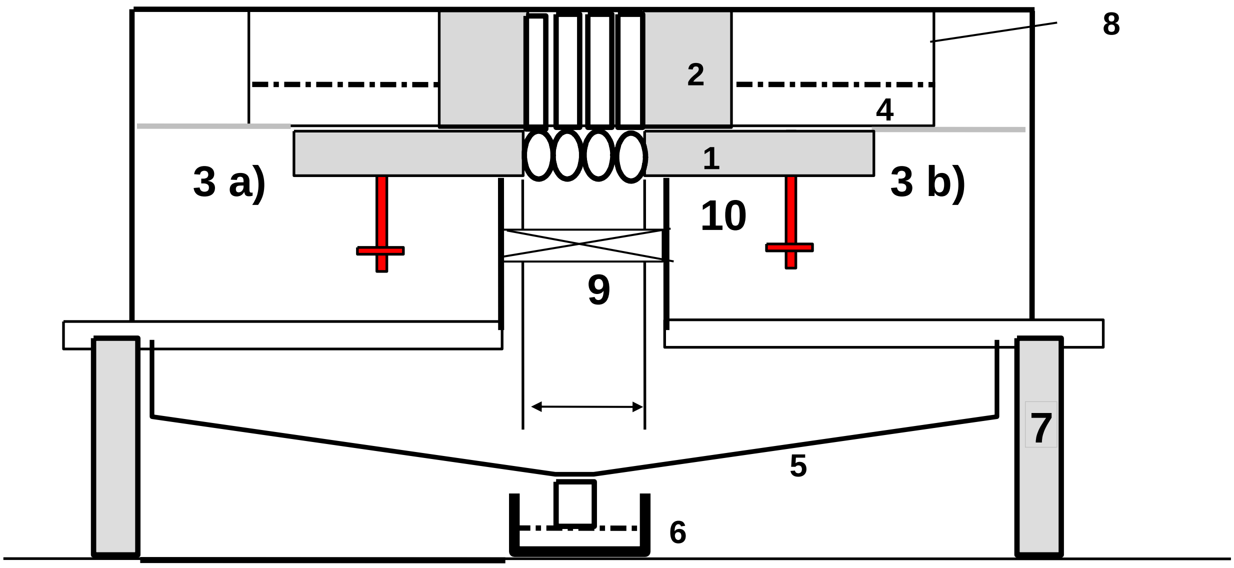


Figure D.10 b: Cross section AA

Key to Figure D.10a and D.10b

1 Expansion joint specimen with, where relevant, longitudinal assembly details
2 Upstand
3 Concrete blocks forming test box a) and b)
4 Height of water H
5 Receptacle
6 Cup
7 Structure of test support
8 Cofferdam or provisionally raised part
9 Opening
10 Part maintaining the joint in opening position

D.4.4 Sample and preparation of test specimens

The preparation of the test specimen is under the responsibility of the manufacturer.

D.4.4.1 Dimensions

The full-scale representative specimen of the expansion joint shall include all components and at least one connection if applicable and an upstand.

The expansion joint sample shall be representative of the assembled expansion joint kit. Where relevant in the expansion joint, the test piece shall comprise assembly details between adjacent parts in the longitudinal direction of the expansion joint. The exact length of the sample shall be fixed by agreement between the manufacturer and the TAB and the testing laboratory according to the type of product.

The minimum length of the test specimen shall be 1 m.

In case a watertight connection between the waterproofing system of the main structure and the expansion joint is part of the assessment, the test specimen shall include this connection and a representative portion of the waterproofing system of the main structure.

D.4.4.2 Installation of specimen on the test frame

The product to be tested shall be installed in the testing rig under the control of the manufacturer and shall comply with the procedure established by the manufacturer for the installation on the test rig.

D.4.4.3 Test rig

The principle of the test rig is shown in Figures D.10a and D.10b.

D.4.5 Test execution procedure

D.4.5.1 Beginning of the test

The test shall be carried out after the materials are fully cured and set in the test rig in accordance with the installation procedure manual, within a time defined by agreement between the manufacturer and the TAB.

D.4.5.2 Test temperature

The temperature during the test shall be between +5 °C and +30 °C.

D.4.5.3 Execution of the test

The opening of the joint shall be fixed at the maximum opening if not defined in another way in the EAD.

Depending on the type of product, the opening is defined for the worst condition for the assessment of the watertightness.

The test is carried out with potable water.

The minimum height of water shall be at least 30 mm at the highest location of the sample, depending on the design of the expansion joint.

The duration of the test is 360 min.

During the testing continuous visual inspection shall be carried out to detect leakage. In the event of leakage the test shall be stopped and the expansion joints is considered as not watertight. Locations where leakage has been observed are to be reported.

D.4.6 Expression of the results

The openings are stated in millimetres.

Times are expressed in minutes. The air temperature during the test is expressed in degrees Celsius.

In case of failure the location and the significance shall be reported.

D.4.7 Test report

The test report shall include at least:

- The origin of the expansion joint to be tested (the name of the manufacturer, the name of the manufacturing plant);
- The model identification (type, theoretical movement capacity, N° of batch);
- A reference to this annex
- Description of the test equipment;
- The date of the preparation of specimens, the date of test and the test mean temperature;

- The statement of principal dimensions which allow for unique identification of the product tested;
- A brief description of the test conditions (head of water, opening applied during test, test duration, description of the sample, ...);
- Test conditions and operational details not envisaged in this document as well as the possible incidents likely to have affected the results.
- Results of watertightness test (pass, fail, leakage location, etc.).

D.5 ASSESSMENT OF DRAINAGE CAPACITY

Where relevant due to the expansion joint kit is including a drainage device, the drainage capacity shall be assessed according to the assessment method described below.

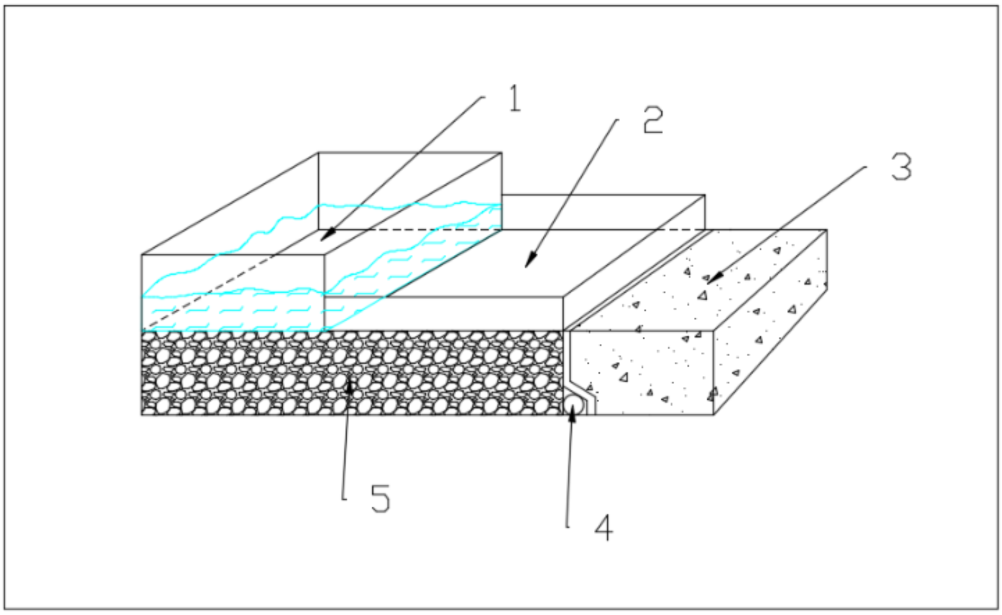


Figure D.11: Description of the test procedure for drainage capacity

Key to Figure D.11:

1 - Water tank, minimum water column height shall be 10 cm and kept constant, width of the tank shall be 50 cm
2 – Watertight surface pavement, width shall be 50 cm
3 - Concrete
4 – Drainage system
5 – Porous pavement (waterproof on its sides), thickness shall be 6 cm

The water tank shall be filled with the drainage device closed. This shall be maintained until the porous pavement is saturated with water. After saturation the drainage device shall be opened and the water level in the tank shall be kept constant. The water shall be collected for 2 hours and the volume is measured.

D.6 ASSESSMENT OF CONTENT, EMMISSION AND/OR RELEASE OF DANGEROUS SUBSTANCES

Leaching tests are conducted according to CEN/TS 16637-2:2014. The leachant shall be pH-neutral demineralised water and the ratio of liquid volume to surface area must be (80 ± 10) l/m².

The test specimen shall be selected according to CEN/TS 16673-2:2014, Clause 8.

In eluates of "6 hours" and "64 days", the following biological tests shall be conducted:

- Acute toxicity test with Daphnia magna Straus according to EN ISO 6341

- Toxicity test with algae according to ISO 15799

- Luminescent bacteria test according to EN ISO 11348-1, EN ISO 11348-2 or EN ISO 11348-3

For each biological test, EC20-values shall be determined for dilution ratios 1:2, 1:4, 1:6, 1:8 and 1:16.

If the parameter TOC is higher than 10 mg/l, the following biological tests shall be conducted with the eluates of "6 hours" and "64 days" eluates:

- Biological degradation according to OECD Test Guideline 301 part A, B or E.

Determined toxicity in biological tests must be expressed as EC20-values for each dilution ratio. Maximum determined biological degradability must be expressed as "…% within …hours/days". The respective test methods for analysis must be specified.

ANNEX E – PRINCIPLES FOR THE ASSESSMENT OF MECHANICAL RESISTANCE

E.1 - SLS/ULS 1: 60 % OF THE MAXIMUM OPENING IN COMBINATION WITH 100 % SLS/ULS LOAD LEVEL

The 60 % opening position is related to the conditions, described with ψ_{Od} = 0,6 for C_{ULS} = 1 according to Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

The 60 % of the maximum opening position (maximum movement capacity) is related to the complete range of movement.

The 100 % ULS load level is related to the conditions, described with ψ_{OT} = 1,0 for C_{ULS} = 1 according to Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

Note 1: The design situation for C_{SLS} is considered to be analogous to C_{ULS} (see also Annex D, Clause D.2.4.3).

Background for derivation of loads for ULS (Annex D, Clause D.2) assessment (see Clause 2.2.1):

The vertical load is 1,35 x 150 kN acting on two wheel prints of 300 mm x 250 mm (contact pressure of 1,35 N/mm²). Where necessary, the load and the wheel print may be reduced, keeping the concerned contact pressure. The horizontal load in the traffic direction (longitudinal) is 0,4 of the vertical test load and the horizontal load perpendicular to the traffic direction (transverse direction) is 0,2 of the vertical test load. If the test specimen is subjected to a combination of vertical and horizontal loads, the combination factors ψ as given in Annex D, Table D.6, apply.

Explanation: The joint shall at least fulfil the mechanical strength at the design load level (= 1,35 – according to EN 1990, Annex A2, Table A2.4 (B) Design values of actions – times the characteristic loads given in Annex D, Table D.3). However there is an uncertainty in the quality of the specimen.

Note 2: Background for derivation of loads for SLS (Annex D, Clause D.2) assessment: (see Clause 2.2.1):

The load shall be derived from a vertical test load being 150 kN acting on two wheel prints of 300 mm x 250 mm (contact pressure of 1,00 N/mm²). Where necessary, the considered load and the considered wheel print may be reduced, keeping the theoretical contact pressure. The considered theoretical horizontal load in traffic direction (longitudinal) is 0,4 (according to Annex D, Clause D.2.3.2.1) of the vertical load and the horizontal load perpendicular to the traffic direction (transverse direction) is 0,2 (according to Annex D, Clause D.2.3.2.2) of the vertical load. If the test specimen is subjected to a combination effect of vertical and horizontal loads, the combination factors ψ as given in Annex D, Table D.6, apply.

E.2 - SLS/ULS 2: 100 % OF THE MAXIMUM OPENING IN COMBINATION WITH 70 % SLS/ULS LOAD LEVEL

The 100 % opening position is related to the conditions, described with ψ_{Od} = 1,0 for C_{ULS} = 2 according to Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

The 70 % ULS load level is related to the conditions, described with ψ_{OT} = 0,7 for C_{ULS} = 2 according to Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

Note: The situation for C_{SLS} is considered to be analogous to C_{ULS} (see also Annex D, Clause D.2.4.3).

E.3 - SITUATION ACCORDING TO ANNEX D, CLAUSE D.2.4.3.2 (FREQUENT COMBINATION)

Depending on the design of the expansion joint, frequent combination may be not considered in the assessment.

E.4 - ALTERNATIVE ASSESSMENT PROCEDURE

This assessment procedure may apply in agreement between manufacturer and TAB.

Instead of assessment according to Clauses E.1 and E.2: opening position: 100 % in combination with 100 % SLS load level (ψ_{Od} and ψ_{OT} = 1,0)

According to Annex D, Clause D.2.4.3.1, SLS1 and SLS2 can be covered by an envelope approach with the condition ψ_{Od} and ψ_{OT} = 1,0.

Relevant for intersecting cantilever surface components only:

For ULS due to the specific situation of level differences at intersecting cantilevers no distinction between ULS1 and ULS2 has to be made. For ULS 100 % load level applies.

ANNEX F – EXAMINATION OF REQUESTED LOAD CYCLES AND REQUESTED LOADS FOR ASSESSMENT OF FATIGUE RESISTANCE FOR A FATIGUE LIFE OF 10, 15, 25 AND 50 YEARS AND UNLIMITED FATIGUE LIFE

F.1 - FOREWORD

The objective of this annex is to give sufficient background information on the used loads and load cycles used in Annex B in conjunction with Annex D, Clause D.2 and EN 1991-2.

Sources: Annex D, Clause D.2.3.3.3 $FLM2_{EJ}$, Table D.5 + N_{obs} according to EN 1991-2, Table 4.5.

Precondition: If for expansion joints for the kit (according to Clause 2.2.2) or parts of them (anchorage) unlimited fatigue life is of relevance $FLM1_{EJ}$ according to Annex D, Clause D.2 applies. If limited fatigue life is of relevance, $FLM2_{EJ}$ according to Annex D, Clause D.2 applies.

This Annex is based on a slope of maximum 4 %.

Method: According to the damage equivalent method used for steel and rubber (equivalent with highest loads).

Note: Fatigue life is the contribution to the working life governed by the fatigue endurance.

F.2 - EQUIVALENT NUMBER OF AXLE RATES FOR EXPANSION JOINTS AND ANCHORAGE SYSTEMS

Table F.1: Idealisation of axle load histogram to maximum axle loads with equivalent numbers of cycles

$Q_{1k,fat}$ Vertical axle load kN	$Q_{1lk,fat}$ Horizontal axle load kN in traffic direction	Axle number rate	Equivalent number of axle rates for vertical loads	Equivalent number of axle rates for horizontal loads	Axle type
100	-	1,1	0,16	-	A
120	-	1,25	0,31	-	C
150	20	0,20	0,10	0,07	B
170	24	0,45	0,32	0,28	B
190	28	0,45	0,45	0,45	B
190	28	Σn_{equ}	1,34	0,80	

Background:

- Horizontal loads are related to traction forces only
- $0,16 = 1,1 \times (100/190)^3$
- $0,07 = 0,20 \times (20/28)^3$
- Exp3 – see Palmgren-Miner hypothesis about damage accumulation (Fictitious: m = 3; related to the situation that most of relevant components are made of steel)

For other materials the appropriate fatigue classifications and S-N-lines shall be derived from standards or testing.

$Q_{1k,fat}$ according to Annex D, Table D.5, including $\Delta\varphi_{fat} = 1,3$

$Q_{1lk,fat}$, including $\Delta\varphi_{fat} = 1,0$

Axle number rate according to Annex D, Table D.5

Background: 500 000 lorries per year >> see N_{obs}:

- 10 = 10 years working life according to category 1 (10 years)
- 15 = 15 years working life according to category 2 (15 years)
- 25 = 25 years working life according to category 3 (25 years)
- 50 = 50 years working life according to category 4 (50 years)

F.3 - CONCLUSION FOR REQUESTED LOAD CYCLES FOR AXLE LOADS ON EXPANSION JOINTS

Fatigue behaviour is tested as a summation of two load categories:

- Vertical loads
- Vertical loads combined with horizontal loads in the traffic direction

1. Load cycle derived from vertical axle load 190 kN (see Table F.1, line 5):

$$\Sigma n = (1{,}34 – 0{,}80) \times 500\,000 \times 10 = 0{,}54 \times 500\,000 \times 10 = 2{,}7 \times 10^6$$

2. Load cycle derived from vertical axle load (190 kN) in combination with horizontal axle load 28 kN (see Table F.1, line 5):

$$\Sigma n = 0{,}80 \times 500\,000 \times 10 = 4 \times 10^6$$

Note 1: Resulting load: $(190^2 + 28^2)^{0.5}$ = 192 kN. Inclination of load application: 8,4°.

Note 2: Table F.1 shows that only the 100 kN up to 150 kN vertical axle loads represent a very small volume of the total axle load cycles. Therefore the Σn for combination of vertical and horizontal loads in sub clause 2 has a relative high value, compared to Σn in sub clause 1 for F_v (see also F_{v+h} and F_v in Tables F.2 and F.3).

F.4 - TEST LOAD (F) FOR EXPANSION JOINTS, BASED ON FLM2$_{EJ}$

1. According to the EN 1991-2 the maximum vertical axle load (190 kN) for FLM2$_{EJ}$ is related to an axle with two dual tyres.

2. The wheel print area of 300 mm x 250 mm according to Annex D, Clause D.2 substitutes a dual tyre print with a related load of 190/4 = 47,5 kN.

3. The related theoretical contact pressure = 47500/(300 x 250) = 0,63 N/mm².

4. The contact pressure for wheels of lorries in practice = 0,8 N/mm² (8 bar internal tyre pressure).

Consequence for the test load to be used:

Due to the geometry and the load path of expansion joints and the need to consider realistic strain intervals in these structures, for expansion joints the contact pressure is considered as the most relevant aspect for fatigue behaviour. In order to assess this, the contact pressure of 0,8 N/mm² needs to be taken into account. This contact pressure is considered to act on a fictitious wheel print of at least 300 mm x 250 mm. The effect of the voids is disregarded.

Consequently, the requested vertical test load F_{Tv} has to be calculated, using an average contact pressure (0,8 N/mm²) and a fictitious contact area not smaller than 300 mm x 250 mm.

5. In order to achieve a reduced number of cycles for testing it is allowed to increase the contact pressure to a maximum of 1,0 N/mm². In such cases, a reduction of load cycles can be calculated as follows: $((0{,}8/p_{requested})^3)$ x load cycles.

Example for $p_{requested}$ = 1,0: $(0{,}8/1{,}0)^3$ = 0,5 x load cycles.

The horizontal test load F_{Th} is calculated as follows: $F_{Th} = (28/190) \times F_{Tv}$

F.5 - TEST LOAD (F) FOR EXPANSION JOINTS, BASED ON FLM1$_{EJ}$

1. According to Annex D, Clause D.2.3.3.2, the maximum vertical axle load is 273 kN for FLM1$_{EJ}$. This is related to a theoretical wheel print of 300 mm x 250 mm.

2. According to Annex D, Clause D.2.3.3.2, the maximum horizontal axle load is 42 kN for FLM1$_{EJ}$.

3. The wheel print area of 300 mm x 250 mm according to Annex D, Clause D.2 is assumed to represent a dual tyre print with a related load of 273/4 = 68,3 kN. According to this the theoretical vertical test load per wheel = 68 kN.

4. The related theoretical contact pressure = 68300/(300 x 250) = 0,91 N/mm². In principle, this covers the contact pressure in practice. If for $FLM1_{EJ}$ the contact pressure is reduced from 0,91 N/mm² to 0,8 N/mm², the associated number of cycles is $(0,91/0,8)^3$ x 5 000 000 = 7,4 x 10^6.

5. In order to achieve a reduced number of cycles for testing it is allowed to increase the contact pressure. Whereas increasing the contact pressure to 1,0 N/mm² is considered appropriate in general. In such cases, a reduction of load cycles can be calculated as follows: $((0,91/p_{requested})^3)$ x load cycles.

Example for $p_{requested}$ = 1,0: $(0,91/1,0)^3$ = 0,75 x load cycles.

Consequence for the test load to be used: The requested vertical test load F_{Tv} has to be calculated, using the internal tyre pressure (0,91 N/mm²) and a contact area not smaller than 300 mm x 250 mm.

The horizontal test load F_{Th} is calculated according to Annex D, Clause D.2.3.3.2, as follows:

$F_{Th} = (0,2/1,3) \times F_{Tv}$.

F.6 - SUMMARIZING TABLE OF CALCULATED LOAD CYCLES FOR DIFFERENT FATIGUE LIVES

For limited fatigue life the accumulated number of cycles is stated in relation to a working life in years according to Annex D, Clause D.2.

For unlimited fatigue life the contact pressure and number of cycles is stated in relation to Annex D, Clause D.2 and EN 1991-2.

Table F.2: Calculated load cycles

Item		**$FLM2_{EJ}$**				**$FLM1_{EJ}$**
		10 years	**15 years**	**25 years**	**50 years**	**Unlimited**
Expansion Joints, including anchorage system (Contact pressure: **0,8** N/mm²)	n_{v+h}	1,7 x 10^6	2,5 x 10^6	4,2 x 10^6	8,4 x 10^6	**7,4 x 10^6**
	n_v	1,1 x 10^6	1,7 x 10^6	2,9 x 10^6	5,8 x 10^6	
Expansion Joints, including anchorage system (Contact pressure: **0,91** N/mm²)	n_{v+h}			-	-	**5 x 10^6**
Remarks					*Number of cycles exceeds those for $FLM1_{EJ}$ (unlimited fatigue life).>> $FLM1_{EJ}$ applies.*	

Boundary assumptions for the derivation of test loads and test cycles in conjunction with the Eurocode traffic load models:

1. No cut-off limits used for the determination of equivalent numbers of cycles and increased loads,

2. For steel m = 3,

3. 1,30 according to dynamic amplification factor ($\Delta\varphi_{fat}$), included in the loads according to Annex D, Clause D.2,

4. n = 5 x 10^6 according to EN 1991 for constant amplitude fatigue limit $\Delta\sigma_D$,

5. V = Vertical axle load, H = Horizontal axle load.

Remark: The 2 x 10^6 load cycles are normally used as a reference level for classification of fatigue for non-elastomeric parts (Wöhler).

Comment on comparison between limited fatigue life 50 years and unlimited fatigue life according to EN 1991: Due to the simplification of the S-N-line in conjunction with the axle load histogram the limited fatigue life testing conditions approach the conditions for unlimited fatigue life for fatigue design lives of approximately 20 years for expansion joints.

F.7 - NUMBER OF LOAD CYCLES FOR DIFFERENT FATIGUE LIVES

Table F.3: Load cycles for assessment of different fatigue lives in relation to the working life categories

Expansion Joints (including anchorage system)		**Number of cycles**				
Test description		**$FLM2_{EJ}$**				**$FLM1_{EJ}$**
		10 years	**15 years**	**25 years**	**50 years**	**Unlimited**
Contact pressure: 0,8 N/mm²	1st stage: vertical and horizontal loads simultaneously applied	$1,7 \times 10^6$	$2,5 \times 10^6$	$4,2 \times 10^6$	$FLM1_{EJ}$ applies	$7,4 \times 10^6$
	2nd stage: vertical loads only applied	$1,1 \times 10^6$	$1,7 \times 10^6$	$2,9 \times 10^6$	--	--
	Envelope approach: vertical and horizontal loads simultaneously applied	$2,8 \times 10^6$	$4,2 \times 10^6$	$7,1 \times 10^6$	$FLM1_{EJ}$ applies	$7,4 \times 10^6$
Contact pressure: 1,0 N/mm² (alternatively to 0,8 N/mm²)	1st stage: vertical and horizontal loads simultaneously applied	$0,87 \times 10^6$	$1,3 \times 10^6$	$2,2 \times 10^6$	$FLM1_{EJ}$ applies	3.8×10^6
	2nd stage: vertical loads only applied	$0,57 \times 10^6$	$0,87 \times 10^6$	$1,5 \times 10^6$	--	--
	Envelope approach: vertical and horizontal loads simultaneously applied	$1,44 \times 10^6$	$2,17 \times 10^6$	$3,7 \times 10^6$	($FLM1_{EJ}$ applies)	$3,8 \times 10^6$

Note 1: For idealisation of the axle load histogram to maximum axle loads with equivalent numbers of cycles m = 3 is used. The use of m = 3 is related to the situation that the load transferring components are made of steel.

Note 2: If horizontal loads can be neglected (see also relevant Clause in the EAD), the total numbers of vertical load cycles become: $2,8 \times 10^6$ (10 years category), $4,2 \times 10^6$ (15 years category) and $7,1 \times 10^6$ (25 years category) for contact pressure = 0,8 N/mm². For 50 years category the total number of cycles related to $FLM1_{EJ}$ applies.

For contact pressure = 1,0 N/mm² a similar simplification applies.

Derivation of test loads from contact pressure:

The load application shall be executed by means of a contact area which simulates the geometry and stiffness of the wheel.

In case of pulsating test: elastomeric pad: ≥ 300 mm x 250 mm:

- Minimum vertical test load per wheel = $A_{min} \times 0,8 = 300 \times 250 \times 0,8 = 60 \times 10^3$ N = 60 kN,

- Corresponding horizontal test load per wheel = (0,2/1,3) x 56 = 8,4 kN,

- The partial factor $\gamma_{F,f} = 1,0$.